APPENDIX A

CURRICULUM VITAE FOR VICTOR J. BIERMAN, JR.

Victor J. Bierman, Jr., Ph.D.

Senior Scientist
LimnoTech

Principal Expertise

- Water Quality
- Eutrophication
- Chemical Fate Assessment
- Toxic Chemical Modeling
- Hydrology
- Regulatory Compliance

Education

Ph.D. Environmental Engineering
University of Notre Dame, Notre Dame, Indiana, 1974

M.S. Physics
University of Notre Dame, Notre Dame, Indiana, 1971

A.B. Science
Villanova University, Villanova, Pennsylvania, 1966

Experience Summary

Dr. Bierman has 35 years of experience in the development and application of water quality models for eutrophication and the transport and fate of toxic chemicals. This work has led to his publication of over 100 technical papers and reports. He is a former Associate Professor in the Department of Civil Engineering at the University of Notre Dame, and a former U.S. EPA National Expert in Environmental Exposure Assessment. As an LTI Senior Scientist, Dr. Bierman conducts research and development on projects for Federal, state and regional government clients. He also provides expert review, litigation support, and expert testimony on a variety of environmental issues for industrial, regulatory and private clients.

Dr. Bierman is a leading expert in the assessment and solution of problems related to nutrients, nuisance algal blooms, nitrogen fixation, hypoxia, exotic species, and ecosystem processes. He has conducted studies in watersheds, lakes, rivers, estuaries and coastal marine systems. This experience has included data synthesis, expert review, and development and application of mass balance models. Dr. Bierman is also a leading expert in toxic chemical transport, fate, partitioning and bioaccumulation. He has conducted assessment studies in major river systems, estuaries, and the Great Lakes, and remedial investigations at U.S. EPA Superfund sites. These studies have included organic chemicals, heavy metals, sediment processes, and mass balance modeling.

Projects conducted by Dr. Bierman include eutrophication studies in the Great Lakes, Saginaw Bay, the Gulf of Mexico, Chesapeake Bay, the Potomac Estuary, Lake Okeechobee and the Florida Everglades. They also include remedial investigations for contaminated sediments at Superfund sites in the Hudson, Fox and Kalamazoo Rivers, and toxic chemical transport and fate studies in the Great Lakes, Green Bay, Saginaw Bay, the Columbia River, and the Delaware and Potomac River Estuaries. Clients have included Federal agencies such as U.S. EPA and the National Oceanic and Atmospheric Administration; regional agencies such as the Metropolitan Washington Council of Governments, South Florida Water Management District, Delaware River Basin Commission, and the Port of Portland; and various other state and local government agencies. Clients have also included private sector industries and environmental organizations.

Key accomplishments by Dr. Bierman include synthesis of results from five different eutrophication models, including his own model of Saginaw Bay, to develop target phosphorus loadings to the Great Lakes as part of the 1978 Water Quality Agreement between the U.S. and Canada; modeling of hypoxia in the Gulf of Mexico to assess the influence of nutrient loadings from the Mississippi River Basin and produced water discharges from oil and gas drilling activities; transport and fate modeling of PCBs as part of the Hudson River Reassessment RI/FS; development of a coupled phytoplankton-exotic species-PCB model of Saginaw Bay, Lake Huron; development of models for PCB total maximum daily loads (TMDLs) for the Delaware and Potomac River Estuaries; modeling of eutrophication and sediment diagenesis in Lake Okeechobee; modeling of phosphorus transport and fate in the Florida Everglades; and development of a model to support a dioxin TMDL in the Columbia River Basin.

Litigation Support within the Last Ten Years

Litigation Support for a Food Processor in the Illinois River Watershed. 2006-Present. Providing consulting and expert witness services pertaining to phosphorus impacts in the Illinois River Watershed.

Litigation Support for a Former Manufactured Gas Plant. 2004-2005. Expert Witness. Provided consulting and expert witness services pertaining to contaminant transport and fate at the site of a former manufactured gas plant.

Litigation Support for an Industrial Discharger on the Ohio River. 2004-2005. Expert Witness. Conducted an investigation of hydrodynamics, sediment transport and chemical transport and fate in the Ohio River. Prepared a written expert opinion report, was deposed, and provided technical review of opposing expert reports.

Litigation Support for Wastewater Treatment Plant Permit Challenge. 2004-2005. Expert Witness. Conducted investigations of constituent transport and fate in the Ohio River, and water quality standards applicable to the Ohio River in Kentucky and Ohio.

Litigation Support for Hudson River Natural Resource Damage Assessment. 2003-2005. Consulting Expert. Investigated PCB transport and fate issues at the U.S. EPA Hudson River Superfund Site for the U.S. Department of Justice.

Litigation Support for U.S. Department of Justice in Case Involving Municipal Discharger. 1994-1995 and 1998-1999. Expert Witness. Conducted transport and fate analysis for solids and toxic chemicals discharged from the Hammond Sanitary District Plant. Prepared written expert opinion report, was deposed, and provided technical review of opposing expert reports.

Litigation Support and Expert Testimony for a Class Action Suit Involving Pesticide Contamination. 1996-1999. Expert Witness. Conducted an assessment of sources, environmental distribution and fate of Mirex at an EPA Superfund Site in Salem, Ohio. Prepared technical affidavit, was deposed, and provided technical review of opposing expert reports.

Compensation

My hourly billing rate for work related to preparation of this expert report is $250. My hourly billing rate for testimony (deposition and trial) is $375.

Professional and Academic Appointments

Senior Scientist 2001-Present	Limno-Tech, Inc. Greensboro, North Carolina
Associate Vice President 1997-2001	Limno-Tech, Inc. Ann Arbor, Michigan
Senior Scientist 1992-1997	Limno-Tech, Inc. South Bend, Indiana
Senior Project Manager 1990-1992	Limno-Tech, Inc. South Bend, Indiana
Adjunct Associate Professor 1990-1992	Dept. of Civil Engineering & Geological Sciences University of Notre Dame, Notre Dame, Indiana
Associate Professor 1986-1990	Department of Civil Engineering University of Notre Dame, Notre Dame, Indiana
Environmental Scientist 1981-1986	Environmental Research Laboratory U.S. Environmental Protection Agency, Narragansett, Rhode Island EPA National Expert in Environmental Exposure Assessment
Adjunct Associate Professor 1985-1986	Department of Civil and Environmental Engineering University of Rhode Island, Kingston, Rhode Island
Environmental Scientist 1974-1981	Large Lakes Research Station U.S. Environmental Protection Agency, Grosse Ile, Michigan
Systems Ecologist 1974	Cranbrook Institute of Science Bloomfield Hills, Michigan
Graduate Student 1968-1973	Departments of Physics & Civil Engineering University of Notre Dame, Notre Dame, Indiana
Science Teacher 1966-1968	Northeast Catholic High School Philadelphia, Pennsylvania

Professional Affiliations

American Chemical Society

Water Environment Federation

Estuarine Research Federation

Society of Environmental Toxicology and Chemistry

North American Lake Management Society

American Society of Limnology and Oceanography

International Association for Great Lakes Research

Aquatic Ecosystem Health and Management Society

Selected Professional Activities

Discussion Group Leader, Chesapeake Bay Program Scientific and Technical Advisory Committee Workshop, Modeling in the Chesapeake Bay Program: 2010 and Beyond, Annapolis, MD, January 17-18 2006.

Co-Chair, Session on Contaminant Fate and Transport, Third International Conference on the Remediation of Contaminated Sediments, New Orleans, Louisiana, January 24-27, 2005.

Chair, Special Session on Total Maximum Daily Load (TMDL) for PCBs: Case Study of the Delaware River Estuary. Water Environment Federation, WEFTEC04, New Orleans, Louisiana, October 6, 2004.

Editorial Board, Aquatic Ecosystem Health & Management, Journal of the Aquatic Ecosystem Health and Management Society. 2003-Present.

Member, Modeling Subcommittee of the Monitoring, Modeling and Research Committee, U.S. EPA Gulf of Mexico Program. 1999-Present. Provide expert assistance on design and implementation of a mathematical modeling program to address scientific and management questions related to hypoxia in the Gulf of Mexico.

Co-Chair, 5th International Symposium on Sediment Quality Assessment, Chicago, Illinois, October 16-18, 2002.

Invited Expert, Lake Michigan Mass Balance Sediment Modeling Workshop, U.S. EPA Great Lakes National Program Office. 2001. Provided expert review and technical guidance on alternate modeling approaches for sediment dynamics in the Lake Michigan Mass Balance Study.

Co-Chair, Task Group 4, Gulf of Mexico Hypoxia Assessment, White House Committee on Environment and Natural Resources. 1998-2000. Conducted a quantitative assessment of water quality responses in the Gulf of Mexico to potential changes in nutrient loadings from the Mississippi River Basin.

Invited Expert, Gulf Hypoxia Science Meeting, Gulf of Mexico Hypoxia Assessment. 1999. Provided expert advice on scientific questions related to causes of hypoxia in the Gulf of Mexico.

Member, Technical Advisory Committee, Nutrient Enhanced Coastal Ocean Productivity (NECOP) Program, NOAA. 1992-1995. Provide coordination and technical guidance for physical and water quality modeling activities in the NECOP Program.

White Paper Author, Workshop on Reducing Uncertainty in Mass Balance Models of Toxics in the Great Lakes: Lake Ontario Case Study. 1992. Invited to author a "white paper" on model formulations, spatial-temporal resolution and process aggregation for the purpose of guiding workshop discussions.

Associate Editor, Journal of Great Lakes Research. 1986-1991.

Discussion Leader, Mass Balance Workshop, International Joint Commission. 1990. Participated in development of management questions to define levels of mass balance modeling of toxic chemicals in the Great Lakes.

Member, Lake Huron Task Force, International Joint Commission. 1986-1990. Participate in development of surveillance plans, conduct data synthesis and prepare summary reports on water quality conditions in Lake Huron, pursuant to the Water Quality Agreements between the U.S. and Canada.

Task Group Leader, Workshop on Nutrient Cycling/Food Web Interactions for Lake Ontario. 1990. Invited to peer review a proposed Nutrient Cycling/Food Web Model for Lake Ontario.

Invited Expert, Workshop on Sediment and Food Web Effects on Bioaccumulation, U.S. EPA. 1990. Invited to review present understanding and future research approach to bioaccumulation of toxic chemicals.

Invited Expert, Workshop on Mississippi River Plume and Louisiana Shelf Interaction, NOAA. 1989. Invited to review a research plan to study nutrient fluxes, biological productivity and dissolved oxygen depletion as part of a new Coastal Ocean Program.

Member, Technical Advisory Committee, International Association for Great Lakes Research. 1986-1988. Assist the Board of Directors in identifying problems and opportunities in pursuit of long-term research programs to support environmental management in the Great Lakes.

Expert Reviewer, Workshop on Toxic Chemical Loadings in the Great Lakes, International Joint Commission. 1987. Invited to peer review results from three different mathematical models for toxic chemical concentrations in the Great Lakes.

Reviewer, National Sea Grant College Site Team, University of Rhode Island. 1987.

Member, Statistics and Modeling Group, Tributary Loading Workshop, International Joint Commission. 1987. Provided recommendations on monitoring plans and loading estimation techniques for tributaries to the Great Lakes.

Invited Expert, Surveillance Workshop, Great Lakes National Program Office, U.S. EPA. 1986. Invited to participate in a review of present activities and to make recommendations for future programs.

Chairman, Water Quality Working Group, Science and Technical Committee, U.S. EPA Narragansett Bay Project. 1985-1986. Provided technical coordination and program review for water quality-related projects.

Member, Science Advisory Committee, Marine Ecosystems Research Laboratory, Graduate School of Oceanography, University of Rhode Island. 1985-1986. Reviewed research accomplishments, current plans and future direction for the MERL, a Center of Excellence under a Cooperative Agreement between the U.S. EPA and the University of Rhode Island.

Member, Water Quality Group, Northeast Monitoring Program, NOAA. 1983-1985. Provided technical assistance on water quality assessments and mathematical modeling in the Middle Atlantic Bight.

Expert Reviewer, Environmental Program, National Marine Fisheries Service, NOAA. 1984. Served as an outside reviewer for the Environmental Assessment Program of the Northeast Fisheries Center.

Panelist, Eutrophication Symposium, New England Estuarine Research Society. 1984. Invited to participate in a discussion of alternative approaches to the study of eutrophication.

Member, Board of Directors, International Association for Great Lakes Research. 1981-1984. Elected for a three-year term.

Associate Editor, Journal of Great Lakes Research. 1979-1983.

Member, Steering Committee for Implementation of Ecosystem Approach Workshop, International Joint Commission. 1981-1982. Served as a technical consultant for ecosystem modeling related to management issues in the Great Lakes.

Member, Technical Advisory Committee, Chesapeake Bay Program, U.S. EPA. 1979-1982. Served as a technical consultant on eutrophication and water quality modeling.

Expert Witness, Public Hearings on Phosphorus Management Strategies for the Great Lakes. International Joint Commission, Windsor, Ontario. 1980.

Ad Hoc Member, Modeling Sub-Group, Phosphorus Management Strategies Task Force, International Joint Commission. 1979. Served as a technical consultant on the scientific basis for development of the target phosphorus loads for the Great Lakes as part of the 1978 Water Quality Agreement.

Member, Task Group III, A Technical Group to Review Phosphorus Loadings, U.S.-Canada Water Quality Agreement Re-Negotiation. 1978. Synthesized results from five different mathematical models and developed target phosphorus loading recommendations for the major basins in the Great Lakes.

Ad Hoc Member, Expert Committee on Ecosystems Aspects, International Joint Commission. 1977. Reviewed the Hydroscience water quality model of Lake Ontario.

Expert Witness, Conservation Committee Hearings, Michigan House of Representatives. 1977. Testified on House Bills 4015 and 4023 to ban phosphates in detergents.

Member, Inter-Agency Technical Advisory Group, U.S. Army Corps of Engineers Lake Erie Project. 1975-1977. Served as a technical consultant on projects related to eutrophication and water quality modeling of Lake Erie.

Participant in U.S.-U.S.S.R. Scientific Exchange Meetings. 1976. Moscow, Novosibirsk, Irkutsk, Baikal and Khabarovsk, U.S.S.R.

Selected Experience

Review of Dioxin Issue Paper for San Francisco Bay. 2008. Senior Scientist. Conducted a scientific peer review of a dioxin issue paper for San Francisco Bay under the direction of the San Francisco Estuary Institute.

Review of Watershed and Water Quality Models for Nutrient TMDLs in the Caloosahatchee River Estuary. 2007-2008. Senior Scientist. Conducted a scientific review of a coupled HSPF-EFDC modeling system for nutrient total maximum daily loads (TMDLs) for the Caloosahatchee River Estuary to ensure that nutrient levels are appropriate for restoration of water quality.

Assessment of Mercury Dynamics in the Florida Everglades. 2006-Present. Project Director. Conducting review of available models for mercury transport, fate and bioaccumulation, and the current scientific understanding of mercury dynamics in the Florida Everglades.

Litigation Support for a Food Processor in the Illinois River Watershed. 2006-Present. Providing consulting and expert witness services pertaining to phosphorus impacts in the Illinois River Watershed.

Chesapeake Bay Water Quality Model. 2004-Present. Project Director. Developing new sub-models for estuarine phosphorus dynamics, pH-alkalinity, and algal speciation for the Potomac portion of the third-generation Chesapeake Bay Water Quality Model.

Expert Assistance on Water Quality Modeling for South Florida Water Management District. 2004-Present. Technical Director, Limno-Tech/HydroQual Joint Venture. Providing task order consulting services for hydrologic, hydraulic and water quality modeling to support Comprehensive Everglades Restoration Programs (CERP) and other District programs.

Expert Assistance on Delaware River PCB Model for Total Maximum Daily Load (TMDL). 2002-Present. Senior Scientist. Providing expert technical assistance to Delaware River Basin Commission on model development, application and data needs to support a TMDL for PCBs in the Delaware River Estuary.

Assessment of EPA-Proposed TMDLs for Nutrients in Lake Okeechobee Tributaries. 2006-2007. Project Director. Conducted forecast simulations with the Lake Okeechobee Water Quality Model (LOWQM) to investigate the impacts of the proposed nutrient TMDLs on nitrogen-fixing blue-green algae in the lake, and providing expert assistance to the Everglades Agricultural Area Environmental Protection District and South Florida Water Management District.

Peer Review of Everglades Landscape Model (ELM). 2006-2007. Scientific Facilitator. Conducted scientific facilitation of an independent peer review of the Everglades Landscape Model and its applicability to decision-making for management of nutrients and hydrology in the Florida Everglades.

Peer Review of a Linked HSPF-AQUATOX Modeling System. 2006. Senior Scientist. Conducted a scientific peer review for U.S. EPA on a demonstration application of a linked HSPF-AQUATOX modeling system as an alternate approach for development of numeric nutrient water quality criteria.

Model for PCB Total Maximum Daily Load (TMDL) in Potomac River Estuary. 2005-2007. Project Director. Development and calibration of a transport and fate model for PCBs in the Potomac River Estuary to support development of a TMDL by District of Columbia, Maryland and Virginia.

Assessment of Impacts of Produced Water Discharges on Gulf of Mexico Hypoxia. 2005-2007. Project Director. Used existing models of Gulf of Mexico hypoxia to estimate incremental impacts of produced water discharges from oil and gas platforms.

Expert Assistance on Chesapeake Bay Water Quality Modeling. 2001-2007. Senior Scientist. Provided expert assistance to Metropolitan Washington Council of Governments by conducting a scientific assessment of the Chesapeake Bay Water Quality Model and its use for developing load allocations for nutrients and solids in the Potomac River and Estuary as part of the Chesapeake 2000 Agreement.

Characterization and Conceptual Site Model for Berry's Creek. 2004-2006. Senior Scientist. Conducted site investigation, data assessment and conceptual modeling to support remediation efforts at Universal Oil Products Superfund Site, Berry's Creek, East Rutherford, New Jersey.

Litigation Support for a Former Manufactured Gas Plant. 2004-2005. Expert Witness. Provided consulting and expert witness services pertaining to contaminant transport and fate at the site of a former manufactured gas plant.

Litigation Support for an Industrial Discharger on the Ohio River. 2004-2005. Expert Witness. Conducted an investigation of hydrodynamics, sediment transport and chemical transport and fate in the Ohio River. Prepared a written expert opinion report, was deposed, and provided technical review of opposing expert reports.

Litigation Support for Wastewater Treatment Plant Permit Challenge. 2004-2005. Expert Witness. Conducted investigations of constituent transport and fate in the Ohio River, and water quality standards applicable to the Ohio River in Kentucky and Ohio.

Water Quality Model to Support Biscayne Bay Feasibility Study. 2004-2005. Project Director. Developed a detailed scope of work for an integrated hydrodynamic, sediment transport and water quality model to support a Phase II Feasibility Study of Biscayne Bay, Florida.

Litigation Support for Hudson River Natural Resource Damage Assessment. 2003-2005. Consulting Expert. Investigated PCB transport and fate issues at the U.S. EPA Hudson River Superfund Site for the U.S. Department of Justice.

Expert Assistance on Offshore Siting Study for Relocation of Wastewater Treatment Plant Outfall. 2002-2005. Senior Scientist. Developed regional-scale nutrient loadings to the northeast continental shelf of the U.S. to support a modeling assessment of the proposed relocation of a wastewater treatment plant outfall currently discharging to Jamaica Bay, New York.

Dynamics of Sediment-Water Nutrient Fluxes in the Lower St. Johns River. 2000-2005. Project Director. Conducted literature and field assessments of phosphorus, nitrogen, carbon and oxygen fluxes in the Lower St. Johns River to support a site-specific water quality model.

Expert Assistance on Modeling of Hypoxia in the Gulf of Mexico. 2004. Project Director. Provided expert assistance to Offshore Operators Committee, EPA Region 6 and Minerals Management Service on use of existing models to estimate impacts of produced water discharges.

Expert Assistance on Urban Stream Total Maximum Daily Load (TMDL). 2002-2003. Member, Stakeholder Advisory Group. Provided expert technical assistance to City of Greensboro on development and review of an HSPF model for a fecal coliform TMDL on North Buffalo Creek.

Expert Assistance on Lower St. Johns River Water Quality Model for Nutrient Total Maximum Daily Load (TMDL). 2002-2003. Senior Scientist. Provided expert technical assistance to St. Johns River Water Management District and the U.S. Army Corps of Engineers on model development, calibration and incorporation of nitrogen fixation.

Effect of Zebra Mussels on Cycling and Potential Bioavailability of PCBs: Case Study of Saginaw Bay. 1998-2002. Co-Principal Investigator. Developed a mass balance model to represent the influence of phytoplankton and zebra mussel dynamics on PCB transport, fate and bioavailability in Saginaw Bay, Lake Huron.

Water Quality Assessment for NPDES Permit, Cape Fear River. 2001. Project Director. Conducted data assessment and modeling analyses for dissolved oxygen to support NPDES permit re-issuance for an industrial discharge to the Middle Cape Fear River, North Carolina.

Modeling of PCB Fate and Transport for Hudson River Reassessment RI/FS. 1993-2001. Project Director. Developed mass balance models for hydraulics, solids and PCBs to investigate the impacts of continued No Action and various remedial scenarios on water column and sediment PCB exposures in the Upper Hudson River. Results were used to support the EPA Record of Decision to remediate contaminated sediments in the Upper Hudson River.

Columbia River Channel Deepening Reconsultation Project. 2001. Project Director. Reviewed available data and modeling analyses for hydrodynamics, sediment transport and toxic chemicals to support development of a Biological Assessment for potential impacts on endangered species.

Ottawa River Environmental Hot Spot Delineation and Risk Assessment. 2000-2001. Project Director. Directed assessment of risks posed by existing conditions in the Ottawa River, Ohio, and identification of priority areas for remediation.

Modeling of PCB Fate and Transport in Kalamazoo River. 1999-2000. Senior Scientist. Provided expert advice on development of mass balance models for transport, fate and bioaccumulation of PCBs in the Kalamazoo River, Michigan.

Lake Michigan Ecosystem Model. 1998-2000. Principal Investigator. Developed an ecosystem mass balance model of the lower food web to support the Lake Michigan Mass Balance Study.

Fox River and Green Bay PCB Fate and Transport Model Evaluation. 1997-2000. Senior Scientist. Provided expert advice and consultation on evaluation of alternate PCB transport and fate models for the Fox River and Green Bay, as set forth in an agreement between the State of Wisconsin and several paper companies.

Gulf of Mexico Hypoxia Assessment, White House Committee on Environment and Natural Resources. 1997-1999. Co-Team Leader, Task Group 4. Developed and calibrated a water quality model for hydraulic transport, primary productivity and dissolved oxygen in the northern Gulf of Mexico to assess responses to potential changes in nutrient loadings from the Mississippi River Basin.

Mass Balance Modeling of Hypoxia on the Louisiana Inner Shelf. 1990-1999. Principal Investigator. Development and calibration of a water quality mass balance model for hydraulic transport, primary productivity and bottom water hypoxia in the Mississippi River Plume/Inner Gulf of Mexico Shelf Region.

Expert Assistance on James River Tributary Strategy. 1997-1999. Senior Scientist. Provided expert assistance in reviewing the revised Chesapeake Bay Water Quality Model to support development of a management strategy for the James River in response to a legislative mandate by the State of Virginia.

Litigation Support for U.S. Department of Justice in Case Involving Municipal Discharger. 1994-1995 and 1998-1999. Expert Witness. Conducted transport and fate analysis for solids and toxic chemicals discharged from the Hammond Sanitary District Plant. Prepared written expert opinion report, was deposed, and provided technical review of opposing expert reports.

Litigation Support and Expert Testimony for a Class Action Suit Involving Pesticide Contamination. 1996-1999. Expert Witness. Conducted an assessment of sources, environmental distribution and fate of Mirex at an EPA Superfund Site in Salem, Ohio. Prepared technical affidavit, was deposed, and provided technical review of opposing expert reports.

Sediment Diagenesis Model for Lake Okeechobee. 1997-1998. Project Director. Developed a sediment diagenesis submodel of phosphorus for incorporation into an existing eutrophication mass balance model for Lake Okeechobee. Provided expert assistance to South Florida Water Management District in model application studies.

Caloosahatchee Estuary Hydrodynamic-Salinity Model. 1997. Project Director. Developed and applied a one-dimensional, coupled, hydrodynamic-salinity model. Provided expert assistance to South Florida Water Management District in model calibration and predictive simulations.

Expert Assistance on Chesapeake Bay Water Quality Modeling. 1996-1997. Senior Scientist. Provided expert assistance to Metropolitan Washington Council of Governments in evaluating the rationale for nutrient reduction goals and in technical review of the Chesapeake Bay Watershed and Water Quality Models.

Application of a Coupled Primary Productivity-Exotic Species Model for Saginaw Bay, Lake Huron. 1996-1997. Principal Investigator. Developed and applied an ecosystem mass balance model to investigate water quality responses to changes in external nutrient loadings and zebra mussel dynamics.

Development of Everglades Water Quality Model. 1995-1997. Project Director. Developed and applied a watershed mass balance model for hydraulics, chloride and total phosphorus for the overland areas and canal system in the Florida Everglades.

Litigation Support and Expert Testimony for a Major Chemical Company in Michigan Involving NPDES Permit Violations. 1996. Expert Witness. Conducted transport, fate and effects analysis for toxic chemicals and phosphorus discharged from an industrial outfall. Prepared expert opinion report, provided depositions for two separate cases, and testified at trial in State Circuit Court.

An Ecosystem Modeling Study of Saginaw Bay: Impacts of Long-Term Loading Reductions and Invasion by the Zebra Mussel. 1991-1994. Principal Investigator. Development and application of a mass balance model to assess relative water quality impacts of reductions in phosphorus loadings and potential impacts caused by zebra mussel invasion.

Expert Assistance on Lake Okeechobee Water Quality Modeling for Lake Management. 1993. Project Director. Provided expert assistance in evaluating modeling results, technical guidance for additional modeling simulations, and co-authorship of two peer-reviewed manuscripts with South Florida Water Management District staff.

Development of Caloosahatchee Estuary Salinity Model. 1993. Project Director. Developed and applied a one-dimensional salinity mass balance model, and determined steady-state salinity profiles in the Caloosahatchee Estuary for a suite of freshwater inflows from Lake Okeechobee.

Limnological Studies of Nitrogen Impacts on the Lake Okeechobee Ecosystem. 1993. Project Director. Conducted literature review, data assessment and empirical modeling to understand and potentially control nitrogen impacts on Lake Okeechobee.

Testing the Use of Mass Balance Models for NPDES Permit Development to Protect Sediment Quality. 1992-1993. Project Director. Development and test site applications of a mass balance modeling framework for implementing sediment quality criteria for hydrophobic organic chemicals and heavy metals.

St. Joseph River Combined Sewer Overflows Impact Assessment for the City of South Bend, Indiana in Support of the Development of Control Strategies. 1991-1993. Senior Scientist. Directed event-driven field sampling program for St. Joseph River and provided guidance on development and application of mass balance models for coliform bacteria and dissolved oxygen.

Evaluation of Potential Impacts of Nitrogen Removal on Eutrophication in the Potomac Estuary. 1991-1993. Project Director. Conducted review of scientific literature, historical data and predictions of Potomac Eutrophication Model (PEM) to assess risk of proliferation of nitrogen-fixing blue-green algae under various point source nitrogen control strategies.

Lake Okeechobee Water Quality Modeling Evaluations. 1992. Project Director. Provided expert assistance in development and application of a water quality model for eutrophication in Lake Okeechobee, Florida.

Peer Review of Everglades Water Quality Research Plan. 1992. Senior Scientist. Provided external peer review of planning components for best management practices (BMPs) and development of watershed mass balance modeling tools for multi-objective management of water resources.

Development and Validation of an Integrated Exposure Model for Toxic Chemicals in Green Bay, Lake Michigan. 1988-1992. Principal Investigator. Developed and applied a suite of individual models to describe hydraulics, eutrophication, particle dynamics and toxic chemicals in the bay.

Development of Phase II Screening Model for TCDD (Dioxin) in the Columbia River. 1991-1992. Project Director. Application of a screening-level mass balance model to support development of a total maximum daily load (TMDL) for dioxin in the Upper and Lower Columbia, Snake and Willamette River Basins.

Evaluation of Potential Impacts on Juday Creek from Proposed Stormwater Detention Basins. 1991. Senior Scientist. Directed field monitoring, data synthesis and mass balance modeling of water and heat in the creek and proposed detention basins.

Expert Consulting and Review of Water Quality Modeling on Lake Mead, Nevada. 1990. Senior Scientist. Conducted peer review of water quality model for eutrophication in Lake Mead.

Toxics Modeling Workshops for Training EPA and State Regulatory Personnel. 1989. Principal lecturer on calibration of toxic chemical models at workshops in U.S. EPA Regions V (Chicago), IX (San Francisco), VIII (Boulder), IV (Atlanta) and X (Seattle), and for E.I. DuPont DeNemours and Company, Newark, Delaware.

Expert Consultant, U.S. Army Corps of Engineers. 1987. Provided expert assistance on selection of aquatic processes and state variables for a time-variable, three-dimensional water quality model of Chesapeake Bay.

Expert Consultant, Ontario Ministry of the Environment. 1987. Provided expert assistance on development of an aquatic food chain model to support the Ontario Municipal Industrial Strategy for Abatement.

Expert Consultant, Chesapeake Bay Program, U.S. EPA. 1984-1986. Provided technical assistance on planning and implementation of a water quality modeling program for nutrient enrichment and dissolved oxygen depletion in Chesapeake Bay.

Program Coordinator, Estuarine Research Program, Environmental Research Laboratory, Narragansett, U.S. EPA. 1984-1986. Conceived, planned and coordinated research in the areas of transport, fate and effects of contaminants and nutrients in estuarine and near-coastal environments.

Project Officer, U.S. Environmental Protection Agency. 1974-1986. Served as Project Officer on 12 research grants and cooperative agreements. Cumulative budgeted amount of this research was $4 million. Results included publication of over 60 scientific papers and reports.

Lead Scientist, Office of Research and Development, U.S. EPA. 1984. Prepared and presented technical briefings on ocean disposal and estuarine research for the Consolidated Water Research Committee as part of the EPA research planning for fiscal years 1985 and 1986.

Program Coordinator, Ocean Disposal Research Program, Environmental Research Laboratory, Narragansett, U.S. EPA. 1983-1984. Conceived, planned and coordinated ocean disposal research in the areas of transport, transformation and fate of ocean-dumped contaminants.

Expert Consultant, Region I, U.S. EPA. 1982-1984. Provided technical assistance on physical transport and food chain modeling for PCBs and heavy metals in support of the New Bedford Harbor (Massachusetts) Superfund Project.

Expert Consultant, Office of Water Regulations and Standards, U.S. EPA. 1982-1983. Developed a scientific protocol for ocean dumpsite designation, and conducted a workshop consisting of scientific and technical experts to peer review the protocol.

Program Manager, Waste Load Allocation Program, Large Lakes Research Station, U.S. EPA. 1980-1981. Initiated studies in the Flint River (Michigan) watershed on the development and field application of waste load allocation models for heavy metals.

Visiting Scientist, International Institute for Applied Systems Analysis, Laxenburg, Austria. 1980. Applied water quality models to Lake Balaton (Hungary) under terms of an International Agreement between the Institute and the Hungarian Academy of Science.

Expert Consultant, National Aeronautics and Space Administration. 1979. Provided technical assistance on the applications of remote sensing imagery to water quality problems in lakes.

Expert Consultant, British Broadcasting Corporation-The Open University Centre. 1979. Provided technical assistance on the use of the Great Lakes as an international case study on phosphorus enrichment, and appeared in a film production entitled, "Inorganic Chemistry Concepts and Case Studies."

Expert Consultant, World Health Organization. 1978. Provided technical assistance on a water quality modeling project for the Billings Reservoir, Sao Paulo, Brazil.

Collaboration, International Institute for Applied Systems Analysis, Laxenburg, Austria. 1978. Transferred a water quality database for Saginaw Bay, Lake Huron, to the Institute for use in mathematical model intercomparisons.

Research Assistant, Department of Civil Engineering, University of Notre Dame. 1971-1972. Provided field sampling and laboratory analytical support for an EPA-sponsored project on Stone Lake, Michigan. Provided technical support and data analysis for an advanced wastewater treatment project sponsored by Telecommunications Industries, Inc., Copiague, Long Island.

Teaching Assistant, Department of Civil Engineering, University of Notre Dame. 1971. Taught an undergraduate laboratory course in air pollution. Constructed a monodisperse aerosol generator and various air sampling devices.

Research Assistant, Department of Physics, University of Notre Dame. 1969. Constructed and tested electronic instrumentation and field-mapped a large bending magnet in support of an NSF-sponsored high-energy physics project at Argonne National Laboratory.

Teaching Assistant, Department of Physics, University of Notre Dame. 1968-1969. Taught undergraduate laboratory courses and tutorial classes.

Science Teacher, Northeast Catholic High School, Philadelphia, Pennsylvania. 1966-1968. Taught lecture and laboratory courses in Physics (11th Grade) and Introductory Physical Science (9th Grade).

Selected Publications

Journal Articles

Predicted Impacts from Offshore Produced Water Discharges on Hypoxia in the Gulf of Mexico. Bierman, V.J., Jr., S.C. Hinz, D. Justić, D. Scavia, J.A. Veil, K. Satterlee III, M.E. Parker and S. Wilson. Society of Petroleum Engineers Projects, Facilities & Construction. 3(2):1-10. 2008.

Forecasting Gulf's Hypoxia: The Next 50 Years? D. Justić, V.J. Bierman, Jr., D. Scavia and R. Hetland. Estuaries and Coasts. 30(5):791-801. 2007.

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The Lake Okeechobee Water Quality Model (LOWQM): Enhancements, Calibration, Validation and Analysis. R.T. James, V.J. Bierman, Jr., M.J. Erickson and S.C. Hinz. Lake and Reservoir Management. 21(3):231-260. 2005.

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Predicted Impacts from Offshore Produced Water Discharges on Hypoxia in the Gulf of Mexico. Prepared for U.S. EPA, Region 6, Dallas, Texas. EPA Contract No. 68-C-03-041. 2006.

Summary of Water Quality Models for Hypoxia in the Gulf of Mexico. Prepared for Offshore Operators Committee, New Orleans, Louisiana. 2004.

Chesapeake Bay Water Quality Model: Summary of Technical Support on Model Calibration and Load Allocations. Prepared for Metropolitan Washington Council of Governments, Washington, D.C. 2003.

Water Quality Assessment for Reissuance of NPDES Permit. Prepared for Smithfield Packing Company, Inc., Tar Heel, North Carolina. 2001.

Ecosystem Model for the Lake Michigan Mass Balance Study. Final Technical Report, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, Illinois. Contract No. 68-R7-5003/0002. 2000.

Revised Baseline Modeling Report, Volume 2D, Books 1 and 2, Hudson River PCBs Reassessment RI/FS. U.S. Environmental Protection Agency, Region II, and U.S. Army Corps of Engineers, Kansas City District. 2000.

Everglades Water Quality Model Calibration Report. Prepared for South Florida Water Management District, West Palm Beach, Florida. 1997.

Application of a Coupled Primary Productivity-Exotic Species Model for Saginaw Bay, Lake Huron. U.S. Environmental Protection Agency, Large Lakes Research Station, Grosse Ile, Michigan. 1997.

Estimated Responses of Water Quality on the Louisiana Inner Shelf to Nutrient Load Reductions in the Mississippi and Atchafalaya Rivers. U.S. Environmental Protection Agency, Gulf of Mexico Program Office, Stennis Space Center, Mississippi. 1995.

A Preliminary Ecosystem Modeling Study of Zebra Mussels (*Dreissena Polymorpha*) in Saginaw Bay, Lake Huron. U.S. Environmental Protection Agency, Large Lakes and Rivers Research Branch, Grosse Ile, Michigan. 1995.

Preliminary Assessment of Nitrogen Impacts on the Lake Okeechobee Ecosystem. Prepared for the South Florida Water Management District, West Palm Beach, Florida. 1993.

Evaluation of Nitrogen Removal Eutrophication Risk for the Freshwater Potomac Estuary. Prepared for Metropolitan Washington Council of Governments, Washington, D.C. 1993.

Phase II Screening Model Application to Dioxin (2,3,7,8-TCDD) in the Columbia River. Prepared for the U.S. Environmental Protection Agency, Region X, Seattle, Washington. 1992.

Screening Level Analysis for Estimation of Sediment Quality Criteria Impacts. Prepared for the Office of Wastewater Enforcement and Compliance, U.S. Environmental Protection Agency, Washington, D.C. 1992.

Awards

James R. Rumsey Award, Michigan Water Environment Association, 1995.
Monetary Awards for Special Achievement, U.S. Environmental Protection Agency, 1981; 1982; 1983; 1984.
Monetary Awards for Scientific and Technical Achievement, U.S. Environmental Protection Agency, 1981; 1982; 1983.
Bronze Medal, U.S. Environmental Protection Agency, 1978.
Quality-Step Merit Award, U.S. Environmental Protection Agency, 1976.
National Wildlife Federation Fellowship, 1972.
National Science Foundation Traineeship, 1969.

Specialized Training and Coursework

Institute on Mathematical Modeling of Water Quality, Manhattan College, New York, 1985.

APPENDIX B

ANALYSIS OF GLEAMS MODEL INPUT FILES

Table B-1. Summaries of Dr. Engel's Plant Nutrient Parameter Input Files for Pasture Land Use

Sources of information:

1) GLEAMS original (initial) parameter input values were extracted from the 1N.PAR files and 2NP.PAR files located in the following directories:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\ORGINPUT
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\OriginInput
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\OriginInput
2) GLEAMS calibrated (final) parameter input values were extracted from the 1N.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*
3) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.
4) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"
5) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.
6) Parameter input value ranges set for the automated calibration procedure via the Shuffled Complex Evolution Algorithm (SCE-UA) were extracted from the "SCE.DAT" file in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders in the following directory: "N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*

Plant Nutrient Parameter Input File for Pasture Land Use (1NP.PAR, 2NP.PAR)
Summary of Original (Initial) Parameter Input Values and Calibrated (Final) Parameter Input Values

Parameter Name	Parameter Description	Unit	Illinois River (Zone 2)[1]		Illinois River (Zone 3)[1]		Baron Fork		Caney Creek		Comment
			Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	
AOM	Organic matter content in animal waste.	%	69.5	69.5	69.5	69.5	21.0	21.0	21.0	21.0	All sub-basin parameter input values were calibrated and constrained between 0.12 and 86.0 using an automated calibration.
APHOS	Total phosphorus content in animal waste.	%	1.70	1.70	1.70	1.70	2.35	2.35	2.35	2.35	All sub-basin parameter input values were calibrated and constrained between 1.664 and 2.496 using an automated calibration.
APORGP	Organic phosphorus content in animal waste.	%	0.95	0.95	0.95	0.95	0.97	0.97	0.97	0.97	All sub-basin parameter input values were calibrated and constrained between 0.95 and 0.99 using an automated calibration.
CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	71.9 68.3 68.2 47.5 43.7	61.7 52.1 45.5 40.7 37.5	133.2 126.6 126.3 88.0 80.9	114.2 96.5 84.3 75.4 69.4	138.6 131.6 130.2 126.4 119.9	61.9 52.3 45.7 40.9 37.6	52.8 50.2 49.7 48.3 45.5	40.0 33.8 29.5 26.4 24.3	Parameter inputs are listed one to five for each soil horizon. Illinois River parameter input values were calibrated and constrained between 100 and 300 using an automated calibration. Baron Fork and Caney Creek parameter input values calibrated and constrained between 80 and 150 using an automated calibration. All sub-basin labile phosphorus input values were manually modified after the automated calibration.
DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units	1077	1066	1077	1066	1099	1077	1037	1077	Illinois River parameter input values were calibrated and constrained between 60.0 and 300 using an automated calibration. Baron Fork and Caney Creek parameter input values were calibrated and constrained between 100 and 120 using an automated calibration.
RATE	Application rate for animal waste.	tn/ha	0.69	0.50	1.29	0.93	1.04	0.59	0.10	0.10	All sub-basin parameter input values were calibrated and constrained between 0.10 and 1.20 using an automated calibration.
RESDW	Crop residue on the ground surface when simulation begins.	kg/ha	3258.6	3258.6	3258.6	3258.6	4362.3	4362.3	62.3	62.3	All sub-basin parameter input values were calibrated and constrained between 0 and 7,000 using an automated calibration.

Abbreviations:

DF GLEAMS default parameter value applied. This parameter input value was not calibrated for this particular land use.
GN Generic or example value from p.191 of the GLEAMS user manual applied unless noted otherwise. This parameter input value was not calibrated for this particular land use.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.

[1]The Illinois River sub-basin is comprised of nutrient loading Zone 2 and Zone 3 (see p. D-17 of Engel's Expert Report). There are separate pasture nutrient input files for Zone 2 and Zone 3. The 1NP.PAR nutrient input file is specified for Zone 2 and the 2NP.PAR file is specified for Zone 3.

Table B-2. Summary of Dr. Engel's Plant Nutrient Parameter Input File for Crop Land Use

Sources of information:

1) GLEAMS original (initial) parameter input values were extracted from the 1N.PAR files located in the following directories:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\ORGINPUT
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\OriginInput
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\OriginInput
2) GLEAMS calibrated (final) parameter input values were extracted from the 1N.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*
3) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.
4) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"
5) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

Plant Nutrient Parameter Input File for Crop Land Use (1NC.PAR)
Summary of Original (Initial) Parameter Input Values and Calibrated (Final) Parameter Input Values

Parameter Name	Parameter Description	Unit	Illinois River		Baron Fork		Caney Creek		Comment
			Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	
AOM	Organic matter content in animal waste.	%	86.0 86.0	86.0 86.0	86.0 86.0	86.0 86.0	86.0 86.0	86.0 86.0	There are two fertilizer applications of animal waste, which requires two separate parameter input values.
APHOS	Total phosphorus content in animal waste.	%	0.82 0.82	0.82 0.82	0.82 0.82	0.82 0.82	0.82 0.82	0.82 0.82	There are two fertilizer applications of animal waste, which requires two separate parameter input values.
APORGP	Organic phosphorus content in animal waste.	%	0.79 0.79	0.79 0.79	0.79 0.79	0.79 0.79	0.79 0.79	0.79 0.79	There are two fertilizer applications of animal waste, which requires two separate parameter input values.
CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	60	60	80	80	60	60	CLAB input values are the same for all soil horizons.
DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units	1091 1140 2100	1091 1140 2100	1091 1140 2100	1091 1140 2100	1091 1140 2100	1091 1140 2100	There are three fertilizer applications, which requires three separate parameter input values. Two fertilizer applications consist of animal waste and one fertilizer application consists of inorganic commerical fertilizer.
RATE	Application rate for animal waste.	tn/ha	5.00 3.00	5.00 3.00	5.00 3.00	5.00 3.00	5.00 3.00	5.00 3.00	There are two fertilizer applications of animal waste, which requires two separate parameter input values.
RESDW	Crop residue on the ground surface when simulation begins.	kg/ha	DF	DF	DF	DF	DF	DF	

Abbreviations:

DF GLEAMS default parameter value applied. This parameter input value was not calibrated for this particular land use.
GN Generic or example value from p.191 of the GLEAMS user manual applied unless noted otherwise. This parameter input value was not calibrated for this particular land use.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.

Table B-3. Summary of Dr. Engel's Plant Nutrient Parameter Input File for Forest Land Use

Sources of information:

1) GLEAMS original (initial) parameter input values were extracted from the 1N.PAR files located in the following directories:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\ORGINPUT
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\OriginInput
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\OriginInput
2) GLEAMS calibrated (final) parameter input values were extracted from the 1N.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*
3) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.
4) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"
5) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

Plant Nutrient Parameter Input File for Forest Land Use (1NF.PAR)
Summary of Original (Initial) Parameter Input Values and Calibrated (Final) Parameter Input Values

Parameter Name	Parameter Description	Unit	Illinois River		Baron Fork		Caney Creek		Comment
			Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	
AOM	Organic matter content in animal waste.	%	NA	NA	NA	NA	NA	NA	
APHOS	Total phosphorus content in animal waste.	%	NA	NA	NA	NA	NA	NA	
APORGP	Organic phosphorus content in animal waste.	%	NA	NA	NA	NA	NA	NA	
CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	10	20	30	20	10	25	CLAB input values are the same for all soil horizons. Labile phosphorus input values were manually modified during the calibration process.
DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units	NA	NA	NA	NA	NA	NA	
RATE	Application rate for animal waste.	tn/ha	NA	NA	NA	NA	NA	NA	
RESDW	Crop residue on the ground surface when simulation begins.	kg/ha	DF	DF	DF	DF	DF	DF	

Abbreviations:
DF GLEAMS default parameter value applied. This parameter input value was not calibrated for this particular land use.
GN Generic or example value from p.191 of the GLEAMS user manual applied unless noted otherwise. This parameter input value was not calibrated for this particular land use.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.

Table B-4. Summary of Dr. Engel's Plant Nutrient Parameter Input File for Urban Land Use

Sources of information:

1) GLEAMS original (initial) parameter input values were extracted from the 1N.PAR files located in the following directories:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\ORGINPUT
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\OriginInput
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\OriginInput
2) GLEAMS calibrated (final) parameter input values were extracted from the 1N.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders:*
"N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*
3) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.
4) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"
5) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

Plant Nutrient Parameter Input File for Urban Land Use (1NU.PAR)
Summary of Original (Initial) Parameter Input Values and Calibrated (Final) Parameter Input Values

Parameter Name	Parameter Description	Unit	Illinois River		Baron Fork		Caney Creek		Comment
			Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	Original Input Value	Calibrated Input Value	
AOM	Organic matter content in animal waste.	%	NA	NA	NA	NA	NA	NA	
APHOS	Total phosphorus content in animal waste.	%	NA	NA	NA	NA	NA	NA	
APORGP	Organic phosphorus content in animal waste.	%	NA	NA	NA	NA	NA	NA	
CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	DF	DF	DF	DF	DF	DF	
DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units	NA	NA	NA	NA	NA	NA	
RATE	Application rate for animal waste.	tn/ha	NA	NA	NA	NA	NA	NA	
RESDW	Crop residue on the ground surface when simulation begins.	kg/ha	DF	DF	DF	DF	DF	DF	

Abbreviations:

DF GLEAMS default parameter value applied. This parameter input value was not calibrated for this particular land use.
GN Generic or example value from p.191 of the GLEAMS user manual applied unless noted otherwise. This parameter input value was not calibrated for this particular land use.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.

Table B-5. Dr. Engel's Plant Nutrient Parameter Input Files for Pasture Land Use

Sources of Information:

1) GLEAMS parameter input values were extracted from the 1N.PAR files and 2NP.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders in the following directory: "N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR*"*

2) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.

3) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CV-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22, 2008"

4) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject: RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

5) Parameter input value ranges set for the automated calibration procedure via the Shuffled Complex Evolution Algorithm (SCE-UA) were extracted from the "SCE.DAT" file in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders in the following directory: "N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR"*

Plant Nutrient Parameter Input File for Pasture Land Use (1NP.PAR, 2NP.PAR)

Card #	Parameter Name	Parameter Description	Unit	Parameter Value: Illinois River (Zone 2)[1]	Parameter Value: Illinois River (Zone 3)[1]	Parameter Value: Baron Fork	Parameter Value: Caney Creek	Source of Parameter Value	Comment
1-3	TITLE	Three 80-character lines of alphanumeric information that identifies the particular computer run. For example, the soil type, the crop rotation, the tillage practices, may be useful in identifying the file and specific GLEAMS application.	No Units					GN	The run description does not provide any information regarding the site-specific application to the IRW. The run description is a generic description that was taken from an example input file on p. 189 of the GLEAMS user manual.
4	NBYR	Beginning year of plant nutrient simulation.	Year	1901	1901	1901	1901	AS	
4	NEYR	Ending year of plant nutrient simulation.	Year	2000	2000	2000	2000	AS	
4	NUTOUT	Code to designate level of printed nutrient output.	No Units	2	2	2	2	AS	
4	FLGROT	Number of years in a crop rotation cycle.	No Units	1	1	1	1	AS	
4	FLGBAL	Code for output of N and P balance at the end each year of simulation.	No Units	0	0	0	0	AS	
5	RESDW	Crop residue on the ground surface when simulation begins.	kg/ha	3258.6	3258.6	4362.3	62.3	CAL	All sub-basin parameter input values were calibrated and constrained between 0 and 7,000 using an automated calibration.
5	RCN	Nitrogen concentration in rainfall.	ppm	0.8	0.8	0.8	0.8	GN	
5	CNI	Concentration of nitrate-nitrogen in irrigation.	ppm					DF	
5	CPI	Concentration of labile-phosphorus in irrigation.	ppm					DF	
6	TN()	Total nitrogen in each soil horizon. (Number of soil horizons = 5)	%	0.055 0.055 0.043 0.043 0.021	0.055 0.055 0.043 0.043 0.021	0.055 0.055 0.043 0.043 0.021	0.055 0.055 0.043 0.043 0.021	GN	Parameter inputs are listed one to five for each soil horizon.
7	CNIT()	Nitrate-nitrogen concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	10 10 7.0 7.0 3.0	10 10 7.0 7.0 3.0	10 10 7.0 7.0 3.0	10 10 7.0 7.0 3.0	GN	Parameter inputs are listed one to five for each soil horizon.
8	POTMN()	Potentially mineralizable nitrogen in each soil horizon. (Number of soil horizons = 5)	kg/ha	150.0 150.0 230.0 230.0 115.0	150.0 150.0 230.0 230.0 115.0	150.0 150.0 230.0 230.6 115.0	150.0 150.0 230.0 230.0 115.0	GN	Parameter inputs are listed one to five for each soil horizon.
9	ORGNW	Organic nitrogen content from animal waste in the plow horizon.	%	0	0	0	0	GN	
10	TP()	Total phosphorus in each soil horizon. (Number of soil horizons = 5)	%					DF	
11	CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	61.7 52.1 45.5 40.7 37.5	114.2 96.5 84.3 75.4 69.4	61.9 52.3 45.7 40.9 37.6	40.0 33.8 29.5 26.4 24.3	CAL	Parameter inputs are listed one to five for each soil horizon. Illinois River parameter input values were calibrated and constrained between 100 and 300 using an automated calibration. Baron Fork and Caney Creek parameter input values calibrated and constrained between 80 and 150 using an automated calibration. All sub-basin labile phosphorus input values were manually modified after the automated calibration.
12	ORGPW	Organic P content from animal waste in plow horizon.	%	0	0	0	0	GN	
13	PDATE	Date that the following parameters are valid, year of the crop rotation cycle and Julian day.	No Units	1001	1001	1001	1001	AS	
14	NF	Number of fertilizer and animal waste applications during the update period.	No Units	1	1	1	1	AS	
14	NTIL	Number of tillage operations during the update period.	No Units	0	0	0	0	AS	
14	DHRVST	Date of crop harvest, year of the crop rotation cycle and Julian day.	No Units	1310	1310	1310	1310	SS	
15	ICROP	Identification number of the crop grown during this cropping period.	No Units	2	2	2	2	SS	Alfalfa-hay is the crop type specified.
15	LEG	Code for legume crop.	No Units	0	0	0	0	DF	
15	PY	Potential yield for the harvestable portion of the crop.	kg/ha	4500	4500	4500	4500	DF	
15	DMY	Dry matter ratio, the ratio of total dry matter production to harvestable portion of the crop.	No Units					DF	
15	CNR	Carbon:nitrogen ratio for the crop.	No Units					DF	
15	RNP	Ratio of crop nitrogen to phosphorus.	No Units					DF	
15	C1	Coefficient in the exponential relation to estimate nitrogen content of the crop.	No Units					DF	
15	C2	Exponent in the exponential relation to estimate nitrogen content of the crop.	No Units					DF	
16	DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units	1066	1066	1077	1077	CAL	Illinois River parameter input values were calibrated and constrained between 60.0 and 300 using an automated calibration. Baron Fork and Caney Creek parameter input values were calibrated and constrained between 100 and 120 using an automated calibration.
16	MFERT	Code for method of fertilization.	No Units	1	1	1	1	AS	Code = 1 indicates that an organic (animal waste or sewage sludge) is applied.
16	METHAP	Code for method of application.	No Units	0	0	0	0	AS	Code = 0 denotes surface application of fertilizer or animal waste.
16	MTYPE	Code for animal waste type.	No Units	15	15	15	15	AS	Code = 15 indicates that the user specifies total N and P, organic N and P, ammonia and soluble phosphorus in animal waste.
17	FN	Fertilizer nitrate.	kg/ha					NA	Card 17 is skipped if animal waste is applied.
17	FNH	Fertilizer ammonia.	kg/ha					NA	Card 17 is skipped if animal waste is applied.
17	FP	Fertilizer phosphorus.	kg/ha					NA	Card 17 is skipped if animal waste is applied.
17	DEPIN	Depth of incorporation.	cm					NA	Card 17 is skipped if animal waste is applied.
17	FRTWAT	Depth of water applied for fertigation.	cm					NA	Card 17 is skipped if animal waste is applied.
18	RATE	Application rate for animal waste.	t/ha	0.56	0.93	0.59	0.1	CAL	All sub-basin parameter input values were calibrated and constrained between 0.10 and 1.20 using an automated calibration.
18	DEPIN	Depth of incorporation.	cm	0	0	0	0	GN	
18	ATN	Total nitrogen in animal waste.	%	2.81	2.81	2.81	2.81	GN	
18	APORGN	Organic nitrogen content in animal waste.	%	2.08	2.08	2.08	2.08	GN	
18	ANH	Ammonia content in animal waste.	%	0.72	0.72	0.72	0.72	GN	
18	APHOS	Total phosphorus content in animal waste.	%	1.70	1.70	2.35	2.35	CAL	All sub-basin parameter input values were calibrated and constrained between 1.664 and 2.496 using an automated calibration.
18	APORGP	Organic phosphorus content in animal waste.	%	0.95	0.95	0.97	0.97	CAL	All sub-basin parameter input values were calibrated and constrained between 0.95 and 0.99 using an automated calibration.
18	AOM	Organic matter content in animal waste.	%	69.5	69.5	21.0	21.0	CAL	All sub-basin parameter input values were calibrated and constrained between 0.12 and 86.0 using an automated calibration.
18	WASTYP	Type of animal waste (e.g., solid, slurry, or liquid).	No Units	1	1	1	1	AS	Code = 1 denotes that waste is in solid form.
19	NTDAY	Date of tillage, year of crop rotation cycle and Julian day.	No Units					NA	
19	LTIL	Code to designate the tillage implement or equipment used.	No Units					NA	
19	DTIL	Depth of tillage.	cm					NA	
19	EFFINC	Efficiency of incorporation of surface residue.	No Units					NA	
19	FMIX	Tillage mixing efficiency.	No Units					NA	

Abbreviations:

AS Application specific parameter value applied to set simulation time periods, output preferences, and parameter codes for particular method applications (e.g., method of fertilization).
DF GLEAMS default parameter value applied.
CAL Calibrated parameter value applied.
GN Generic or example value from p. 189 of the GLEAMS user manual applied unless noted otherwise.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.
SS Site-specific parameter value applied.

[1]The Illinois River sub-basin is comprised of nutrient loading Zone 2 and Zone 3 (see p. D-17 of Engel's Expert Report). There are separate pasture nutrient input files for Zone 2 and Zone 3. The 1NP.PAR nutrient input file is specified for Zone 2 and the 2NP.PAR file is specified for Zone 3.

Table B-6. Dr. Engel's Plant Nutrient Parameter Input File for Crop Land Use

Sources of information:
1) GLEAMS parameter input values were extracted from the INC.PAR files located in the ILLINOIS, BARRONFORK and CANEYCREEK sub-folders in the following directory: "N:\ERWI_IRW\Expert_Reports\Engel\Materials\Illinois_Final\1.1 FUTURE_1001RUN"
2) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199
3) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller. Expert Report of Dr. B. Engel. For State of Oklahoma, In Case No. 05-CV-329 GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma). Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering. May 21,2008."
4) E-mail correspondence on Wednesday, August 13, 2008 4:37 AM, From David Page; To Robert George, Louis Bulliot, David Riggs, Elizabeth Claire Xidis; Subject: RE: Follow-Up Items from July 11 Teleconference with Dr. Engel

Plant Nutrient Parameter Input File for Crop Land Use (INC.PAR)

Card #	Parameter Name	Parameter Description	Unit	Parameter Value			Source of Parameter Value	Comment
				Illinois River	Baron Fork	Caney Creek		
1-3	TITLE	Three 80-character lines of alphanumeric information that identifies the particular computer run. For example, the soil type, the crop rotation, the tillage practices, may be useful in identifying the file and specific GLEAMS application.	No Units				GN	The run description does not provide any information regarding the site-specific application to the IRW. The run description is a generic description that was taken from an example input file on p. 189 of the GLEAMS user manual.
4	NBYR	Beginning year of plant nutrient simulation.	Year	1901	1901	1901	AS	
4	NEYR	Ending year of plant nutrient simulation.	Year	2000	2000	2000	AS	
4	NUTOUT	Code to designate level of printed nutrient output.	No Units	1	1	1	AS	
4	FLGROT	Number of years in a crop rotation cycle.	No Units	1	1	1	AS	
4	FLGBAL	Code for output of N and P balance at the end each year of simulation.	No Units	0	0	0	AS	
5	RESDW	Crop residue on the ground surface when simulation begins.	kg/ha				DF	
5	RCN	Nitrogen concentration in rainfall.	ppm				DF	
5	CNI	Concentration of nitrate-nitrogen in irrigation.	ppm				DF	
5	CPI	Concentration of labile phosphorus in irrigation.	ppm				DF	
6	CNO	Total nitrogen in each soil horizon. (Number of soil horizons = 5)	%				DF	
7	CNITO	Nitrate-nitrogen concentration in each soil horizon. (Number of soil horizons = 5)	µg/g				DF	
8	POTMN0	Potentially mineralizable nitrogen in each soil horizon. (Number of soil horizons = 5)	kg/ha				DF	
9	ORGNW	Organic nitrogen content from animal waste in the plow horizon.	%				DF	
10	CPO	Total phosphorus in each soil horizon. (Number of soil horizons = 5)	%				DF	
11	CLAB$_i$	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	µg/g	60	60	60	CAL	CLAB input values are the same for all soil horizons. Labile phosphorus input values were manually modified during the calibration process.
12	ORGPW	Organic P content from animal waste in plow horizon.	%				DF	
[illegible]								
13	PDATE	Date that the following parameters are valid, year of the crop rotation cycle and Julian day	No Units	1001	1001	1001	GN	
14	NF	Number of fertilizer and animal waste applications during the update period.	No Units	2	2	2	GN	
14	NTIL	Number of tillage operations during the update period.	No Units	3	3	3	GN	
14	DHRVST	Date of crop harvest, year of the crop rotation cycle and Julian day	No Units	1244	1244	1244	GN	
15	ICROP	Identification number of the crop grown during this cropping period.	No Units	20	20	20	GN	Corn grain is the crop type specified.
15	LEG	Code for legume crop.	No Units				DF	
15	PY	Potential yield for the harvestable portion of the crop	kg/ha				DF	
15	DMY	Dry matter ratio, the ratio of total dry matter production to harvestable portion of the crop.	No Units				DF	
15	CNR	Carbon-nitrogen ratio for the crop.	No Units				DF	
15	RNP	Ratio of crop nitrogen to phosphorus.	No Units				DF	
15	C1	Coefficient in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
15	C2	Exponent in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
16	DF	Date of fertilizer application, year of the crop rotation and Julian day	No Units	1091 1140	1091 1140	1091 1140	GN	There are two fertilizer applications of animal waste. The first DF (1091) is for the first application and the second DF (1140) is for the second application. Note that each subsequent input parameter value will have two inputs, one for each fertilizer application.
16	MFERT	Code for method of fertilization	No Units	1 1	1 1	1 1	GN	Code = 1 indicates that an organic (animal waste or sewage sludge) is applied.
16	METHAP	Code for method of application.	No Units	1 0	1 0	1 0	GN	Code = 1 denotes incorporated fertilizer or animal waste. Code = 0 denotes surface application of fertilizer or animal waste.
16	MTYPE	Code for animal waste type.	No Units	2 2	2 2	2 2	GN	Code = 2 indicates that dairy cattle animal waste in solid form is applied.
17	FN	Fertilizer nitrate.	kg/ha				NA	Card 17 is skipped if animal waste is applied.
17	FNH	Fertilizer ammonia.	kg/ha				NA	Card 17 is skipped if animal waste is applied.
17	FP	Fertilizer phosphorus.	kg/ha				NA	Card 17 is skipped if animal waste is applied.
17	DEPIN	Depth of incorporation.	cm				NA	Card 17 is skipped if animal waste is applied.
17	FRTWAT	Depth of water applied for fertigation.	cm				NA	Card 17 is skipped if animal waste is applied.
18	RATE	Application rate for animal waste.	t/ha	5.00 3.00	5.00 3.00	5.00 3.00	GN	
18	DEPIN	Depth of incorporation	cm	10 0	10 0	10 0	GN	
18	ATN	Total nitrogen in animal waste.	%	4.40 4.40	4.40 4.40	4.40 4.40	GN	
18	APORGN	Organic nitrogen content in animal waste.	%	3.32 3.32	3.32 3.32	3.32 3.32	GN	
18	ANH	Ammonia content in animal waste.	%	1.06 1.06	1.06 1.06	1.06 1.06	GN	
18	APHOS	Total phosphorus content in animal waste.	%	0.82 0.82	0.82 0.82	0.82 0.82	GN	
18	APORGP	Organic phosphorus content in animal waste.	%	0.79 0.79	0.79 0.79	0.79 0.79	GN	
18	AOM	Organic matter content in animal waste.	%	86.0 86.0	86.0 86.0	86.0 86.0	GN	
18	WASTYP	Type of animal waste (e.g., solid, slurry, or liquid).	No Units	1 1	1 1	1 1	GN	Code = 1 denotes that waste is in solid form.
19	NTDAY	Date of tillage, year of crop rotation cycle and Julian day	No Units	1091 1091 1255	1091 1091 1255	1091 1091 1255	GN	Three entries are specified for three separate tillage operations. The first NTDAY (1091) is for the first tillage operation, the second NTDAY (1091) is for the second tillage operation, and the third NTDAY (1255) is for the third tillage operation. Note that each subsequent input parameter value will have three inputs, one for each tillage operation.
19	LTIL	Code to designate the tillage implement or equipment used.	No Units	10 22 10	10 22 10	10 22 10	GN	
19	DTIL	Depth of tillage.	cm	10 4 15	10 4 15	10 4 15	GN	
19	EFFINC	Efficiency of incorporation of surface residue.	No Units				DF	
19	FMIX	Tillage mixing efficiency.	No Units				DF	
[illegible]								
13	PDATE	Date that the following parameters are valid, year of the crop rotation cycle and Julian day	No Units	2001	2001	2001	GN	
14	NF	Number of fertilizer and animal waste applications during the update period.	No Units	1	1	1	GN	
14	NTIL	Number of tillage operations during the update period.	No Units	3	3	3	GN	
14	DHRVST	Date of crop harvest, year of the crop rotation cycle and Julian day.	No Units	2300	2300	2300	GN	
15	ICROP	Identification number of the crop grown during this cropping period.	No Units	58	58	58	GN	Soybeans row crop is the crop type specified.
15	LEG	Code for legume crop.	No Units				DF	
15	PY	Potential yield for the harvestable portion of the crop	kg/ha				DF	
15	DMY	Dry matter ratio, the ratio of total dry matter production to harvestable portion of the crop.	No Units				DF	
15	CNR	Carbon-nitrogen ratio for the crop.	No Units				DF	
15	RNP	Ratio of crop nitrogen to phosphorus.	No Units				DF	
15	C1	Coefficient in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
15	C2	Exponent in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
16	DF	Date of fertilizer application, year of the crop rotation and Julian day	No Units	2100	2100	2100	GN	There are two fertilizer applications of animal waste. The first DF (1091) is for the first application and the second DF (1140) is for the second application.
16	MFERT	Code for method of fertilization.	No Units	0	0	0	GN	Code = 0 indicates that an inorganic (commercial) fertilizer is applied.
16	METHAP	Code for method of application.	No Units	1	1	1	GN	Code = 1 denotes incorporated fertilizer or animal waste.
16	MTYPE	Code for animal waste type.	No Units				NA	
17	FN	Fertilizer nitrate.	kg/ha	0	0	0	GN	
17	FNH	Fertilizer ammonia.	kg/ha	33	33	33	GN	
17	FP	Fertilizer phosphorus.	kg/ha	41	41	41	GN	
17	DEPIN	Depth of incorporation.	cm	10	10	10	GN	
17	FRTWAT	Depth of water applied for fertigation.	cm				DF	
18	RATE	Application rate for animal waste.	t/ha				NA	Card 18 is skipped if commercial fertilizer is applied.
18	DEPIN	Depth of incorporation.	cm				NA	Card 18 is skipped if commercial fertilizer is applied.
18	ATN	Total nitrogen in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	APORGN	Organic nitrogen content in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	ANH	Ammonia content in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	APHOS	Total phosphorus content in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	APORGP	Organic phosphorus content in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	AOM	Organic matter content in animal waste.	%				NA	Card 18 is skipped if commercial fertilizer is applied.
18	WASTYP	Type of animal waste (e.g., solid, slurry, or liquid)	No Units				NA	Card 18 is skipped if commercial fertilizer is applied.
19	NTDAY	Date of tillage, year of crop rotation cycle and Julian day	No Units	2100 2100 2305	2100 2100 2305	2100 2100 2305	GN	Three entries are specified for three separate tillage operations. The first NTDAY (2100) is for the first tillage operation, the second NTDAY (2100) is for the second tillage operation, and the third NTDAY (2305) is for the third tillage operation. Note that each subsequent input parameter value will have three inputs, one for each tillage operation.
19	LTIL	Code to designate the tillage implement or equipment used	No Units	4 22 10	4 22 10	4 22 10	GN	
19	DTIL	Depth of tillage.	cm	15 4 15	15 4 15	15 4 15	GN	
19	EFFINC	Efficiency of incorporation of surface residue.	No Units				DF	
19	FMIX	Tillage mixing efficiency.	No Units				DF	

Abbreviations:

AS Application specific parameter value applied to set simulation time periods, output preferences, and parameter codes for particular method applications (e.g., method of fertilization).
DF GLEAMS default parameter value applied.
CAL Calibrated parameter value applied.
GN Generic or example value from p. 190 of the GLEAMS user manual applied unless noted otherwise.
NA Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.
SS Site-specific parameter value applied.

Table B-7. Dr. Engel's Plant Nutrient Parameter Input File for Forest Land Use

Sources of information:

1) GLEAMS parameter input values were extracted from the 1N PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders in the following directory: "N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR*"*

2) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.

3) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CV-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"

4) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

Plant Nutrient Parameter Input File for Forest Land Use (1NF.PAR)

Card #	Parameter Name	Parameter Description	Unit	Parameter Value			Source of Parameter Value	Comment
				Illinois River	Baron Fork	Caney Creek		
1-3	TITLE	Three 80-character lines of alphanumeric information that identifies the particular computer run. For example, the soil type, the crop rotation, the tillage practices, may be useful in identifying the file and specific GLEAMS application.	No Units				GN	The run description does not provide any information regarding the site-specific application to the IRW. The run description is a generic description that was taken from an example input file on p. 189 of the GLEAMS user manual.
4	NBYR	Beginning year of plant nutrient simulation.	Year	1901	1901	1901	AS	
4	NEYR	Ending year of plant nutrient simulation.	Year	2000	2000	2000	AS	
4	NUTOUT	Code to designate level of printed nutrient output.	No Units	2	2	2	AS	
4	FLGROT	Number of years in a crop rotation cycle.	No Units	1	1	1	AS	
4	FLGBAL	Code for output of N and P balance at the end each year of simulation.	No Units	0	0	0	AS	
5	RESDW	Crop residue on the ground surface when simulation begins.	kg/ha				DF	
3	RCN	Nitrogen concentration in rainfall.	ppm				DF	
5	CNI	Concentration of nitrate-nitrogen in irrigation.	ppm				DF	
5	CPI	Concentration of labile-phosphorus in irrigation.	ppm				DF	
6	TN()	Total nitrogen in each soil horizon. (Number of soil horizons = 5)	%				DF	
7	CNIT()	Nitrate-nitrogen concentration in each soil horizon. (Number of soil horizons = 5)	ug/g				DF	
8	POTMN()	Potentially mineralizable nitrogen in each soil horizon. (Number of soil horizons = 5)	kg/ha				DF	
9	ORGNW	Organic nitrogen content from animal waste in the plow horizon.	%				DF	
10	TP()	Total phosphorus in each soil horizon. (Number of soil horizons= 5)	%				DF	
11	CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g	20	20	25	CAL	CLAB input values are the same for all soil horizons. Labile phosphorus input values were manually modified during the calibration process.
12	ORGPW	Organic P content from animal waste in plow horizon.	%				DF	
13	PDATE	Date that the following parameters are valid, year of the crop rotation cycle and Julian day.	No Units	1001	1001	1001	GN	
14	NF	Number of fertilizer and animal waste applications during the update period.	No Units				DF	
14	NTIL	Number of tillage operations during the update period.	No Units				DF	
14	DHRVST	Date of crop harvest, year of the crop rotation cycle and Julian day.	No Units				DF	
15	ICROP	Identification number of the crop grown during this cropping period.	No Units	69	69	69	GN	Trees-conifer is the crop type specified.
15	LEG	Code for legume crop.	No Units				DF	
15	PY	Potential yield for the harvestable portion of the crop.	kg/ha				DF	
15	DMY	Dry matter ratio, the ratio of total dry matter production to harvestable portion of the crop.	No Units				DF	
15	CNR	Carbon:nitrogen ratio for the crop.	No Units				DF	
15	RNP	Ratio of crop nitrogen to phosphorus.	No Units				DF	
15	C1	Coefficient in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
15	C2	Exponent in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
16	DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units				NA	
16	MFERT	Code for method of fertilization.	No Units				NA	
16	METHAP	Code for method of application.	No Units				NA	
16	MTYPE	Code for animal waste type.	No Units				NA	
17	FN	Fertilizer nitrate.	kg/ha				NA	
17	FNH	Fertilizer ammonia.	kg/ha				NA	
17	FP	Fertilizer phosphorus.	kg/ha				NA	
17	DEPIN	Depth of incorporation.	cm				NA	
17	FRTWAT	Depth of water applied for fertigation.	cm				NA	
18	RATE	Application rate for animal waste.	tn/ha				NA	
18	DEPIN	Depth of incorporation.	cm				NA	
18	ATN	Total nitrogen in animal waste.	%				NA	
18	APORGN	Organic nitrogen content in animal waste.	%				NA	
18	ANH	Ammonia content in animal waste.	%				NA	
18	APHOS	Total phosphorus content in animal waste.	%				NA	
18	APORGP	Organic phosphorus content in animal waste.	%				NA	
18	AOM	Organic matter content in animal waste.	%				NA	
18	WASTYP	Type of animal waste (e.g., solid, slurry, or liquid).	No Units				NA	
19	NTDAY	Date of tillage, year of crop rotation cycle and Julian day.	No Units				NA	
19	LTIL	Code to designate the tillage implement or equipment used.	No Units				NA	
19	DTIL	Depth of tillage.	cm				NA	
19	EFFINC	Efficiency of incorporation of surface residue.	No Units				NA	
19	FMIX	Tillage mixing efficiency.	No Units				NA	

Abbreviations:

AS	Application specific parameter value applied to set simulation time periods, output preferences, and parameter codes for particular method applications (e.g., method of fertilization).
DF	GLEAMS default parameter value applied.
CAL	Calibrated parameter value applied.
GN	Generic or example value from p.191 of the GLEAMS user manual applied unless noted otherwise.
NA	Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.
SS	Site-specific parameter value applied.

Table B-8. Dr. Engel's Plant Nutrient Parameter Input File for Urban Land Use

Sources of information:

1) GLEAMS parameter input values were extracted from the 1N.PAR files located in the ILLINOIS, BARRONFORT, and CANEYCREEK sub-folders in the following directory: "N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR*"*

2) Knisel, W.G. and Davis, F.M. 2000. GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), Version 3.0, User Manual. Pub. No. SEWRL-WGK/FMD-050199.

3) "Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CV-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"

4) E-mail correspondence on Wednesday, August 13, 2008 8:27 AM; From David Page; To Robert George, Louis Bullock, David Riggs, Elizabeth Claire Xidis; Subject, RE: Follow Up Items from July 11 Teleconference with Dr. Engel.

Plant Nutrient Parameter Input File for Urban Land Use (1NU.PAR)

Card #	Parameter Name	Parameter Description	Unit	Parameter Value			Source of Parameter Value	Comment
				Illinois River	Baron Fork	Caney Creek		
1-3	TITLE	Three 80-character lines of alphanumeric information that identifies the particular computer run. For example, the soil type, the crop rotation, the tillage practices, may be useful in identifying the file and specific GLEAMS application.	No Units				GN	The run description does not provide any information regarding the site-specific application to the IRW. The run description is a generic description that was taken from an example input file on p. 189 of the GLEAMS user manual.
4	NBYR	Beginning year of plant nutrient simulation.	Year	1901	1901	1901	AS	
4	NEYR	Ending year of plant nutrient simulation.	Year	2000	2000	2000	AS	
4	NUTOUT	Code to designate level of printed nutrient output.	No Units	2	2	2	AS	
4	FLGROT	Number of years in a crop rotation cycle.	No Units	1	1	1	AS	
4	FLGBAL	Code for output of N and P balance at the end each year of simulation.	No Units	0	0	0	AS	
5	RESDW	Crop residue on the ground surface when simulation begins.	kg/ha				DF	
5	RCN	Nitrogen concentration in rainfall.	ppm				DF	
5	CNI	Concentration of nitrate-nitrogen in irrigation.	ppm				DF	
5	CPI	Concentration of labile-phosphorus in irrigation.	ppm				DF	
6	TN()	Total nitrogen in each soil horizon. (Number of soil horizons = 5)	%				DF	
7	CNIT()	Nitrate-nitrogen concentration in each soil horizon. (Number of soil horizons = 5)	ug/g				DF	
8	POTMN()	Potentially mineralizable nitrogen in each soil horizon. (Number of soil horizons = 5)	kg/ha				DF	
9	ORGNW	Organic nitrogen content from animal waste in the plow horizon.	%				DF	
10	TP()	Total phosphorus in each soil horizon. (Number of soil horizons= 5)	%				DF	
11	CLAB()	Labile phosphorus concentration in each soil horizon. (Number of soil horizons = 5)	ug/g				DF	
12	ORGPW	Organic P content from animal waste in plow horizon.	%				DF	
13	PDATE	Date that the following parameters are valid, year of the crop rotation cycle and Julian day.	No Units	1001	1001	1001	GN	
14	NF	Number of fertilizer and animal waste applications during the update period.	No Units	0	0	0	GN	
14	NTIL	Number of tillage operations during the update period.	No Units	0	0	0	GN	
14	DHRVST	Date of crop harvest, year of the crop rotation cycle and Julian day.	No Units	10366	10366	10366	AS	
15	ICROP	Identification number of the crop grown during this cropping period.	No Units	2	2	2	AS	Alfalfa-hay is the crop type specified.
15	LEG	Code for legume crop.	No Units				DF	
15	PY	Potential yield for the harvestable portion of the crop.	kg/ha				DF	
15	DMY	Dry matter ratio, the ratio of total dry matter production to harvestable portion of the crop.	No Units				DF	
15	CNR	Carbon:nitrogen ratio for the crop.	No Units				DF	
15	RNP	Ratio of crop nitrogen to phosphorus.	No Units				DF	
15	C1	Coefficient in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
15	C2	Exponent in the exponential relation to estimate nitrogen content of the crop.	No Units				DF	
16	DF	Date of fertilizer application, year of the crop rotation and Julian day.	No Units				NA	
16	MFERT	Code for method of fertilization.	No Units				NA	
16	METHAP	Code for method of application.	No Units				NA	
16	MTYPE	Code for animal waste type.	No Units				NA	
17	FN	Fertilizer nitrate.	kg/ha				NA	
17	FNH	Fertilizer ammonia.	kg/ha				NA	
17	FP	Fertilizer phosphorus.	kg/ha				NA	
17	DEPIN	Depth of incorporation.	cm				NA	
17	FRTWAT	Depth of water applied for fertigation.	cm				NA	
18	RATE	Application rate for animal waste.	t/ha				NA	
18	DEPIN	Depth of incorporation.	cm				NA	
18	ATN	Total nitrogen in animal waste.	%				NA	
18	APORGN	Organic nitrogen content in animal waste.	%				NA	
18	ANH	Ammonia content in animal waste.	%				NA	
18	APHOS	Total phosphorus content in animal waste.	%				NA	
18	APORGP	Organic phosphorus content in animal waste.	%				NA	
18	AOM	Organic matter content in animal waste.	%				NA	
18	WASTYP	Type of animal waste (e.g., solid, slurry, or liquid).	No Units				NA	
19	NTDAY	Date of tillage, year of crop rotation cycle and Julian day.	No Units				NA	
19	LTIL	Code to designate the tillage implement or equipment used.	No Units				NA	
19	DTIL	Depth of tillage.	cm				NA	
19	EFFINC	Efficiency of incorporation of surface residue.	No Units				NA	
19	FMIX	Tillage mixing efficiency.	No Units				NA	

Abbreviations:

AS	Application specific parameter value applied to set simulation time periods, output preferences, and parameter codes for particular method applications (e.g., method of fertilization).
DF	GLEAMS default parameter value applied.
CAL	Calibrated parameter value applied.
GN	Generic or example value from p. 191 of the GLEAMS user manual applied unless noted otherwise.
NA	Not applicable. Parameter input value may not be required if certain model attributes are not selected. For example, parameter inputs required for fertilizer application would not be required if a particular land use or field is not fertilized.
SS	Site-specific parameter value applied.

APPENDIX C

LOADEST RESULTS FOR PHOSPHORUS LOADS TO LAKE TENKILLER

Table C-1. Total P Loads for Illinois River near Tahlequah for 1997-2006 Estimated Using LOADEST

Illinois River at Tahlequah LOADEST-Estimated Annual TP Loads in pounds					
			Corrected LOADEST Results -		
Year	**Engel Expert Report Table 5.3**	**Engel Produced Materials (i.e., p_model_10_15.xls)**	**Middle Year**	**First Year**	**Third Year**
1997	211,467	not presented	168,072	232,534	no result
1998	422,906	406,124	504,682	292,349	318,794
1999	392,336	376,767	404,724	433,715	527,948
2000	771,454	740,840	857,099	858,316	973,574
2001	456,947	438,814	509,853	532,085	557,311
2002	301,474	289,511	341,368	387,119	340,387
2003	94,684	90,927	107,375	114,172	124,336
2004	631,798	606,727	652,712	626,108	563,502
2005	258,021	247,782	240,690	236,909	212,516
2006	128,415	123,319	104,636	no result	120,086

Table C-2. Total P Loads for Baron Fork at Eldon for 1997-2006 Estimated Using LOADEST

Baron Fork at Eldon LOADEST-Estimated Annual TP Loads in pounds					
			Corrected LOADEST Results -		
Year	**Engel Expert Report Table 5.3**	**Engel Produced Materials (i.e., p_model_10_15.xls)**	**Middle Year**	**First Year**	**Third Year**
1997	25,500	not presented	25,560	51,360	no result
1998	39,887	38,304	103,020	75,536	49,836
1999	49,755	47,781	60,118	67,600	63,303
2000	298,307	286,470	409,358	438,860	584,858
2001	98,931	95,006	111,653	105,981	102,643
2002	52,666	50,576	60,839	92,570	66,107
2003	10,107	9,706	10,725	9,610	12,517
2004	459,054	440,838	432,887	414,406	344,516
2005	68,639	65,915	65,131	73,938	59,867
2006	58,300	55,986	55,376	no result	54,087

Table C-3. Total P Loads for Caney Creek near Barber for 1997-2006 Estimated Using LOADEST

Caney Creek near Barber LOADEST-Estimated Annual TP Loads in pounds					
			Corrected LOADEST Results -		
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	Middle Year	First Year	Third Year
1997	4,140	not presented	incomplete data	incomplete data	incomplete data
1998	9,024	8,665	7,929	9,264	incomplete data
1999	8,349	8,017	9,091	13,854	10,062
2000	55,787	53,573	42,920	49,545	18,926
2001	36,616	35,163	34,461	37,382	35,770
2002	16,574	15,916	14,143	7,774	13,018
2003	3,485	3,347	2,997	2,595	3,893
2004	57,086	54,821	14,961	67,053	19,266
2005	14,004	13,448	15,165	16,116	6,541
2006	10,574	10,154	11,563	no result	11,772

Table C-4. Sum of Total P Loads for Illinois River, Baron Fork and Caney Creek for 1997-2006 Estimated Using LOADEST

Totaled IRW LOADEST-Estimated Annual TP Loads in pounds					
			Corrected LOADEST Results -		
Year	**Engel Expert Report Table 5.3**	**Engel Produced Materials (i.e., p_model_10_15.xls)**	**Middle Year**	**First Year**	**Third Year**
1997	241,107	not presented	incomplete data	incomplete data	incomplete data
1998	471,817	453,093	615,632	377,149	incomplete data
1999	450,440	432,566	473,932	515,168	601,313
2000	1,125,548	1,080,883	1,309,377	1,346,721	1,577,358
2001	592,494	568,983	655,967	675,448	695,723
2002	370,714	356,003	416,349	487,464	419,513
2003	108,276	103,980	121,096	126,377	140,746
2004	1,147,938	1,102,386	1,100,560	1,107,567	927,284
2005	340,664	327,145	320,986	326,963	278,924
2006	197,289	189,459	171,574	no result	185,945

Table C-5. Total P Loads for the Illinois River near Tahlequah for 2005-2007 Estimated Using LOADEST

Illinois River at Tahlequah LOADEST-Estimated Annual TP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" TP Loads (LOADEST applied to 2005-2007)
2005	258,021	247,782	273,155	270,427	270,389	236,909
2006	128,415	123,319	104,476	103,364	103,244	104,636
2007 (Jan-Sep)	not presented	not presented	149,953	150,076	149,558	146,166

Table C-6. Total P Loads for Baron Fork at Eldon for 2005-2007 Estimated Using LOADEST

Baron Fork at Eldon LOADEST-Estimated Annual TP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" TP Loads (LOADEST applied to 2005-2007)
2005	68,639	65,915	69,930	69,714	69,762	73,938
2006	58,300	55,986	62,844	59,430	59,355	55,376
2007 (Jan-Sep)	not presented	not presented	65,003	63,732	63,706	54,040

Table C-7. Total P Loads for Caney Creek near Barber for 2005-2007 Estimated Using LOADEST

Caney Creek near Barber at LOADEST-Estimated Annual TP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" TP Loads (LOADEST applied to 2005-2007)
2005	14,004	13,448	16,365	16,388	16,358	16,116
2006	10,574	10,154	11,995	12,396	12,353	11,563
2007 (Jan-Sep)	not presented	not presented	13,382	6,248	6,243	8,897

Table C-8. Sum of Total P Loads for the Illinois River, Baron Fork and Caney Creek for 2005-2007 Estimated Using LOADEST

Totaled IRW LOADEST-Estimated Annual TP Loads in pounds						
Year	**Engel Expert Report Table 5.3**	**Engel Produced Materials (i.e., p_model_10_15.xls)**	**1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions**	**Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)**	**Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)**	**"Corrected" TP Loads (LOADEST applied to 2005-2007)**
2005	340,664	327,145	359,451	356,530	356,509	326,963
2006	197,289	189,459	179,315	175,189	174,951	171,574
2007 (Jan-Sep)	not presented	not presented	228,338	220,057	219,506	209,103

Table C-9. SRP Loads for the Illinois River near Tahlequah for 2005-2007 Estimated Using LOADEST

Illinois River at Tahlequah - SRP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" SRP Loads (LOADEST applied to 2005-2007)
2005	not presented	not presented	132,506	129,620	129,620	107,900
2006	not presented	not presented	72,939	71,623	71,623	65,987
2007 (Jan-Sep)	not presented	not presented	104,890	104,410	104,410	94,253

Table C-10. SRP Loads for Baron Fork at Eldon for 2005-2007 Estimated Using LOADEST

Baron Fork at Eldon - SRP Loads in pounds						
Year	**Engel Expert Report Table 5.3**	**Engel Produced Materials (i.e., p_model_10_15.xls)**	**1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions**	**Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)**	**Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)**	**"Corrected" SRP Loads (LOADEST applied to 2005-2007)**
2005	not presented	not presented	18,773	18,780	18,780	11,834
2006	not presented	not presented	17,996	14,144	14,144	9,752
2007 (Jan-Sep)	not presented	not presented	20,039	18,079	18,079	11,520

Table C-11. SRP Loads for Caney Creek near Barber for 2005-2007 Estimated Using LOADEST

Caney Creek near Barber - SRP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" SRP Loads (LOADEST applied to 2005-2007)
2005	not presented	not presented	6,866	6,870	6,870	3,165
2006	not presented	not presented	4,264	4,249	4,249	2,067
2007 (Jan-Sep)	not presented	not presented	5,798	3,364	3,364	2,894

Table C-12. Sum of SRP Loads for the Illinois River, Baron Fork and Caney Creek for 2005-2007 Estimated Using LOADEST

Totaled IRW Main Tributary SRP Loads in pounds						
Year	Engel Expert Report Table 5.3	Engel Produced Materials (i.e., p_model_10_15.xls)	1/6/2008 AMLE Loads Provided by Engel to Wells to Develop Boundary Conditions	Dr. Wells Model Calibration Tributary Run 200 Inputs (May 2008 Expert Report)	Dr. Wells Model Calibration Tributary Run 400 Inputs (8/26/2008 Errata)	"Corrected" SRP Loads (LOADEST applied to 2005-2007)
2005	not presented	not presented	158,146	155,270	155,270	122,899
2006	not presented	not presented	95,198	90,016	90,016	77,806
2007 (Jan-Sep)	not presented	not presented	130,727	125,853	125,853	108,667

APPENDIX D

ERRORS IN GLEAMS MODEL INPUT AND OUTPUT FILES

Table D-1. Errors in Setting Simulation Time Periods for Hydrology Input Files in Dr. Engel's GLEAMS Scenario Runs

GLEAMS Scenario Output Review is Based on the Following Produced Files/Materials:
1) N:\IRWLAWI\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT
2) N:\IRWLAWI\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR_NOLitter\BARRONFORT
3) N:\IRWLAWI\Expert_Reports\Engel\Materials\Gleams_Final\1.2.FUTURE_50YR_GrowthPoultry\ILLINOIS
4) N:\IRWLAWI\Expert_Reports\Engel\Materials\Gleams_Final\2.LAST_50YR_variable Litter\ILLINOIS
5) N:\IRWLAWI\Expert_Reports\Engel\Engel_Errata\Engel_Errata_090408\1.1.FUTURE_100YR_NOLitterCleanSoil.zip\1.1.FUTURE_100YR_NOLitterCleanSoil\BARRONFORT
6) "HRU_Summary" worksheet in this workbook

Summary of Errors in Setting the Simulation Period in GLEAMS Hydrology Input Files

Scenario Description	*GLEAMS Scenario Name*	*Subwatershed*	*Simulation Period (as specified in GLEAMS)*	*Simulation Period (intended for GLEAMS)*	*"HXX.PAR"*	*Land Use (as specified in GLEAMS)*	*Drainage Area (acres) (as specified in GLEAMS)*	*Notes*
Waste for Growth	1.2.FUTURE_50YR_GrowthPoultry	Illinois River	1956-2012	1950-2006	H15.PAR	pasture	3,023.6	HBDATE (1956) & HBYR (1950)/HEYR (2006) are mismatched in the hydrology input file.
Historical	2.LAST_50YR_variable Litter	Illinois River	1956-2006	1950-2006	H15.PAR	pasture	3,023.6	HBDATE (1956) & HBYR (1950)/HEYR (2006) are mismatched in the hydrology input file.
Continued Waste Application	1.1.FUTURE_100YR	Baron Fork	1950-2006	1901-2000	H18.PAR	forest	20,658.6	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.
Continued Waste Application	1.1.FUTURE_100YR	Baron Fork	1950-2006	1901-2000	H19.PAR	forest	6,011.2	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Baron Fork	1950-2006	1901-2000	H18.PAR	forest	20,658.6	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Baron Fork	1950-2006	1901-2000	H19.PAR	forest	6,011.2	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Baron Fork	1950-2006	1901-2000	H18.PAR	forest	20,658.6	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Baron Fork	1950-2006	1901-2000	H19.PAR	forest	6,011.2	Incorrect simulation period specified for HBDATE (1950) & HBYR (1950)/HEYR (2006) inputs.

Definitions for Abbreviations:
NA = Not applicable
HBDATE = The beginning date (year and Julian day) for hydrology simulation.
HBYR = Beginning year of hydrology simulation, used to set rotation for reuse of parameters.
HEYR = Ending year of hydrology simulation, used to set rotation feature.

Table D-2. Errors in Simulation Outputs for Hydrology and Nutrient Files for Dr. Engel's GLEAMS Scenario Runs

GLEAMS Scenario Hydrology and Nutrient Output Review is Based on the Following Produced Files/Materials:
1) N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR; subfolders "ILLINOIS", "BARRONFORT", and "CANEYCREEK"
2) N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.1.FUTURE_100YR_NOLitter; subfolders "ILLINOIS", "BARRONFORT", and "CANEYCREEK"
3) N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\1.2.FUTURE_50YR_GrowthPoultry; subfolders "ILLINOIS", "BARRONFORT", and "CANEYCREEK"
4) N:\IRWLAW1\Expert_Reports\Engel\Materials\Gleams_Final\2.LAST_50YR_variable Litter; subfolders "ILLINOIS", "BARRONFORT", and "CANEYCREEK"
5) N:\IRWLAW1\Expert_Reports\Engel\Engel_Errata\Engel_Errata_090408\1.1.FUTURE_100YR_NOLitterCleanSoil.zip\1.1.FUTURE_100YR_NOLitterCleanSoil.; subfolders "ILLINOIS", "BARRONFORT", and "CANEYCREEK"
6) "HRU_Summary" worksheet in this workbook

Summary of Simulation Output Errors in GLEAMS Hydrology (HXX.OUT) and Nutrient (NXX.OUT) Output Files

Scenario Description	GLEAMS Scenario Name	Subwatershed	Simulation Period (as specified in GLEAMS)	"HXX.OUT"	"HXX.OUT" End Date for Output (Year, Day)	"NXX.OUT"	"NXX.OUT" End Date for Output (Year, Day)	Land Use (as specified in GLEAMS)	Drainage Area (acres) (as specified in GLEAMS)	Notes
Continued Waste Application	1.1.FUTURE_100YR	Baron Fork	1901-2000	H15.OUT	1922, 355	N15.OUT	1922, 358	urban	236.6	
Continued Waste Application	1.1.FUTURE_100YR	Caney Creek	1901-2000	H01.OUT	1915, 075	N01.OUT	1915, 085	pasture	20,658.60	
Continued Waste Application	1.1.FUTURE_100YR	Caney Creek	1901-2000	H04.OUT	1955, 048	N04.OUT	1955, 050	urban	862.5	
Continued Waste Application	1.1.FUTURE_100YR	Illinois River	1901-2000	H04.OUT	NA	N04.OUT	NA	crop	145.9	No output for hydrology or nutrients
Continued Waste Application	1.1.FUTURE_100YR	Illinois River	1901-2000	H16.OUT	1923, 007	N16.OUT	1923, 008	urban	7,955.1	
Continued Waste Application	1.1.FUTURE_100YR	Illinois River	1901-2000	H20.OUT	1923, 007	N20.OUT	1923, 008	urban	539.3	
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Baron Fork	1901-2000	H15.OUT	1922, 355	N15.OUT	1922, 358	urban	236.6	
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Caney Creek	1901-2000	H04.OUT	1955, 048	N04.OUT	1955, 050	urban	862.5	
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Illinois River	1901-2000	H04.OUT	NA	N04.OUT	NA	crop	145.9	No output for hydrology or nutrients
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Illinois River	1901-2000	H16.OUT	1923, 007	N16.OUT	1923, 008	urban	7,955.1	
Waste Application Cessation	1.1.FUTURE_100YR_NOLitter	Illinois River	1901-2000	H20.OUT	1923, 007	N20.OUT	1923, 008	urban	539.3	
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Baron Fork	1901-2000	H15.OUT	1922, 355	N15.OUT	1922, 358	urban	236.6	
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Caney Creek	1901-2000	H04.OUT	1955, 048	N04.OUT	1955, 050	urban	862.5	
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Illinois River	1901-2000	H04.OUT	NA	N04.OUT	NA	crop	145.9	No output for hydrology or nutrients
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Illinois River	1901-2000	H16.OUT	1923, 007	N16.OUT	1923, 008	urban	7,955.1	
No Waste + Background Soil P	1.1.FUTURE_100YR_NOLitter_CleanSoil	Illinois River	1901-2000	H20.OUT	1923, 007	N20.OUT	1923, 008	urban	539.3	
Waste for Growth	1.2.FUTURE_50YR_GrowthPoultry	Baron Fork	1950-2006	H15.OUT	1962, 007	N15.OUT	1962, 010	urban	236.6	
Waste for Growth	1.2.FUTURE_50YR_GrowthPoultry	Illinois River	1950-2006	H04.OUT	NA	N04.OUT	NA	crop	145.9	No output for hydrology or nutrients
Waste for Growth	1.2.FUTURE_50YR_GrowthPoultry	Illinois River	1950-2006	H16.OUT	1972, 007	N16.OUT	1972, 008	urban	7,955.1	
Waste for Growth	1.2.FUTURE_50YR_GrowthPoultry	Illinois River	1950-2006	H20.OUT	1972, 007	N20.OUT	1972, 008	urban	539.3	
Historical	2.LAST_50YR_variable Litter	Baron Fork	1950-2006	H15.OUT	1973, 099	N15.OUT	1973, 102	urban	236.6	
Historical	2.LAST_50YR_variable Litter	Illinois River	1950-2006	H04.OUT	NA	N04.OUT	NA	crop	145.9	No output for hydrology or nutrients
Historical	2.LAST_50YR_variable Litter	Illinois River	1950-2006	H16.OUT	1999, 007	N16.OUT	1999, 007	urban	7,955.1	
Historical	2.LAST_50YR_variable Litter	Illinois River	1950-2006	H20.OUT	1999, 007	N20.OUT	1999, 007	urban	539.3	

Definitions for Abbreviations:
NA = Not applicable

APPENDIX E

PARTIAL SUMMARY OF MISCELLANEOUS ERRORS AND LACK OF DOCUMENTATION

"Expert Report" refers to "Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E. Professor of Agricultural and Biological Engineering, May 22,2008"

"Expert Report – Errata September, 4, 2008" refers to "Errata to Poultry Waste Generation and Land Application in the Illinois River Watershed and Phosphorus Loads to the Illinois River Watershed Streams and Rivers and Lake Tenkiller, Expert Report of Dr. B. Engel, For State of Oklahoma, In Case No. 05-CU-329-GKF-SAJ, State of Oklahoma v. Tyson Foods, et al. (In the United States District Court for the Northern District of Oklahoma), Dr. B. Engel, P.E., Professor of Agricultural and Biological Engineering, September 4, 2008."

"Expert Report – Correction to Errata September, 4, 2008" refers to "Correspondence between David Page and Robert George on October 17, 2008, subject RE: Engel Errata & Declaration"

The list below provides a summary of errors, internal inconsistencies, incorrect unit conversions, incorrect labeling and missing or incomplete documentation in the application of the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model and the routing model to the Illinois River Watershed (IRW) by Dr. Bernard Engel.

1. On Page D-4 in Appendix D of the expert report, Table 1 lists the rainfall stations used to develop rainfall inputs for the GLEAMS model application to the Illinois River, Baron Fork and Caney Creek subwatersheds. However, the rainfall stations listed under each subwatershed do not match the actual rainfall stations used to develop the rainfall inputs required to simulate hydrology with the GLEAMS model. Below is a comparison between the weather station table provided in Table 1 on Page D-4 of the expert report and a corrected table with the actual rainfall stations used to develop rainfall inputs for Illinois River, Baron Fork and Caney Creek subwatersheds.

   Table 1. Weather stations used to model Baron Fork, Illinois River, and Caney Creek Basins.

   (Original table as provided on Page D-4 in Appendix D of the expert report.)

	Baron Fork	Illinois River	Caney Creek
Rainfall Stations	035354, 348506	032444, 344672, 348677	348506
Temperature Stations	9450	9450	9450

   (Corrected table with the actual rainfall stations used in the GLEAMS model application for each subwatershed. The red font indicates the rainfall stations that were not listed as sources of rainfall data in the expert report.)

	Baron Fork	Illinois River	Caney Creek
Rainfall Stations	035354, 348506, 344672, 348677	035354, 348506, 344672, 348677	035354
Temperature Stations	9450	9450	9450

In addition to the missing rainfall stations listed above, rainfall data from station 32444 (also 032444), listed under the Illinois River subwatershed in Table 1, were never used to develop rainfall inputs for GLEAMS model application to the Illinois River subwatershed.

2. The approach used to develop rainfall inputs for the IRW GLEAMS model application is provided on Page D-4 in Appendix D of the expert report; however, the approach that is described on Page D-4 is inconsistent with the actual approach used to develop the GLEAMS rainfall inputs, and is also inconsistent with Figure 4 on Page D-6 in Appendix D of the expert report.

The description of the approach used to develop rainfall inputs for the IRW GLEAMS model application in the expert report is as follows:

> "There are several weather stations in the Illinois River Basin. Various precipitation patterns need to be considered in GLEAMS model application. Therefore, the distribution of weather gage station was generated as Arcview (GIS) point data using latitude and longitude information of weather stations at the NCDC website (Figure 4). Thessien polygons for the weather stations were generated using the weather station gage location data (Figure 4) to identify appropriate rainfall gages to use for locations within the Illinois River Watershed. All weather stations have not been monitored continuously and most weather stations which are being monitored for rainfall have not been monitored for temperature at the same station. Table 1. Shows the selected weather stations which are operated currently."

The approach described in the expert report indicates that "Thessien polygons for the weather stations were generated … to identify appropriate rainfall gages to use for locations within the Illinois River Watershed." However, based on a review of the IRW GLEAMS model input files, one rainfall input deck (PCP01.dat, from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ ...subfolders "ILLINOIS", BARRONFORT", and "CANEYCREEK") is based on rainfall data from a single rainfall station (35354, also 035354). This rainfall input deck (PCP01.dat) was applied to the entire Caney Creek subwatershed drainage area, to approximately 1/3 of the Baron Fork subwatershed drainage area, and to approximately 1/2 of the Illinois River subwatershed drainage area.

In addition, a second rainfall input deck (PCP10.dat, from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ ...subfolders "ILLINOIS", BARRONFORT") is based on a compilation of rainfall data from the various rainfall stations listed in Table 1 (i.e., the second rainfall input deck was compiled using 39 months of data from 35354 (or 035354), 68 months of data from 348506, 11 months of data from 348677, and 2 months of data from 344672.). This rainfall input deck (PCP10.dat) was applied to approximately 2/3 of the Baron Fork subwatershed drainage area and to approximately 1/2 of the Illinois River subwatershed drainage area.

The rainfall input decks described above (PCP01.dat and PCP10.dat) were used as inputs to the IRW GLEAMS model in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory: Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

Also, in addition to the inconsistency between the rainfall input development approach that was described in the expert report and what was actually done in the IRW GLEAMS model application, the rainfall stations listed for the Illinois River subwatershed are inconsistent between Table 1 on Page D-4 and Figure 4 on Page D-6. The rainfall stations listed in Table 1 include: 32444 (also 032444), 344672 and 348677. In contrast, the IRW (Illinois River, Baron Fork and Caney Creek subwatersheds) map overlain with the Thiessen polygons in Figure 4 indicate that the rainfall stations for the Illinois River subwatershed include: 32444 (also 032444), 344672, 348677, 348506, and 35354 (also 035354).

3. The number of total poultry houses in the study area (3,536) used to calculate the rate of total litter applied in each zone (1,2,3 and 4) on Page D-18 in Appendix D of the expert report is not the same number of total poultry houses in the study area (3,662) listed on Page D-15 in Appendix D of the expert report.

4. In the GLEAMS model, the hydrology input files have an input parameter named FOREST, which requires the user to indicate whether the field being modeled is an agricultural site or a forestry site. In the IRW GLEAMS model application, the Illinois River subwatershed hydrology input file for crop (H04.PAR) has a FOREST code of 3, which tells the model that the field is a mixed pine-hardwood forest. The correct FOREST code should be 0, which would tell the model that the field is an agricultural field. This error is present in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory: Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

5. In the IRW GLEAMS model application, the Illinois River subwatershed hydrology input file for HRU 11 (H11.PAR, from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\H11.PAR) contains an incorrect land use description. The description field in the hydrology input file indicates that the land use being modeled is pasture; however, the FOREST parameter input value specified in the hydrology input file (FOREST = 1, tells the model that the site is a long leaf conifer forest) and the nutrient input file specified (1NF.PAR) for HRU 11 indicates that the land use modeled is actually forest and not pasture. This error is present in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory: Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

6. In the IRW GLEAMS model application, the Illinois River subwatershed hydrology input file for HRU 01 (H01.PAR, from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\H01.PAR) contains a drainage area that is inconsistent with the drainage area listed for HRU 01 in the "code_ILL.xls" file (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\GLEAMS\Application\Runoff_Cal\Illinois River\ code_ILL.xls). The drainage area for HRU 01 in the H01.PAR file is 8,048.20 acres. The drainage area for HRU 01 in the "code_ILL.xls" file is 80,438.2 acres. This inconsistency is present in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory: Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

7. The following Baron Fork HRU's were found to have duplicate drainage areas specified in the GLEAMS hydrology input files (e.g., HXX.PAR): HRU 6 and HRU 16, HRU 7 and HRU 17, HRU 8 and HRU 18, HRU 9 and HRU 19, and HRU 10 and HRU 20 (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ BARRONFORT\....HXX.PAR). This error is present in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory:

Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

The table below provides a summary of the duplicate drainage areas (highlighted in gray) for the HRU's listed above.

Subwatershed	*HRU*	*Land Use*	*Drainage Area (ha)*	*Drainage Area (acres)*
Baron Fork	1	pasture	2886.028	7131.4
Baron Fork	2	pasture	5788.891	14304.4
Baron Fork	3	pasture	4253.04	10509.3
Baron Fork	4	pasture	312.9491	773.3
Baron Fork	5	urban	11.97891	29.6
Baron Fork	6	urban	52.28634	***129.2***
Baron Fork	7	forest	888.6654	***2195.9***
Baron Fork	8	forest	7160.76	***17694.301***
Baron Fork	9	forest	2432.691	***6011.2***
Baron Fork	10	forest	8.984185	***22.2***
Baron Fork	11	pasture	30088.92	74350
Baron Fork	12	pasture	353.2565	872.9
Baron Fork	13	pasture	83.4477	206.2
Baron Fork	14	pasture	2922.126	7220.6
Baron Fork	15	urban	95.75036	236.6
Baron Fork	16	urban	52.28634	*129.2*
Baron Fork	17	forest	888.6654	*2195.9*
Baron Fork	18	forest	7160.76	*17694.301*
Baron Fork	19	forest	2432.691	*6011.2*
Baron Fork	20	forest	8.984185	*22.2*
Baron Fork	1-20	Total Area	67,883.16	*167,739.90*

8. In the IRW GLEAMS model application, the Illinois River subwatershed hydrology input file for HRU 15 (H15.PAR) in the waste for growth scenario (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.2.FUTURE_50YR_GrowthPoultry\ILLINOIS\H15.PAR) and the historical scenario (from produced materials Engel\Original_Expert_Report\Produced_Considered_Materials Materials\Gleams_Final\2.LAST_50YR_variable Litter\ILLINOIS\H15.PAR) contains an incorrect parameter input value for HBDATE, which tells the model the beginning date for the hydrology simulation. The parameter input value for HBDATE specified in the H15.PAR file is HBDATE=195600 (Year=1956). The correct year in the beginning date for the hydrology simulation is HBDATE=1950000 (Year=1950) based on the HBYR parameter input value (HBYR=1950, Year=1950), which tells the model the beginning year of the hydrology simulation in the H15.PAR input file. The error in

setting the year in HBDATE resulted in an incorrect simulation period for HRU 15 in both the waste for growth and historical scenarios (see Table D-1, Appendix D).

9. In the IRW GLEAMS model application, the Baron Fork subwatershed hydrology input files for HRU 18 (H18.PAR) and HRU 19 (H19.PAR) in the continued waste application scenario (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ BARRONFORT\H18.PAR and … \H19.PAR) have the wrong simulation period specified. The simulation period for HRU 18 and HRU 19 is set at 1950-2006 (56 years); however, the correct simulation period (as specified in the other GLEAMS hydrology inputs files HXX.PAR) is 1901-2000 (100 years) (see Table D-1, Appendix D).

10. In the IRW GLEAMS model application, the Illinois River subwatershed hydrology (H04.OUT) and nutrient (N04.OUT) output files for crop do not generate any hydrology or nutrient output in any of the GLEAMS model scenarios that the expert report is based upon (see Table D-2, Appendix D). This error is present in all of the scenario model runs ("1.1.FUTURE_100YR", "1.1.FUTURE_100YR_NOLitter", "1.2.FUTURE_50YR_GrowthPoultry", and "2.LAST_50YR_variable Litter" located in the following directory: Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final and "1.1.FUTURE_100YR_NOLitterCleanSoil" located in the following directory: Engel\First_Errata\Produced_Considered_Materials).

11. In the IRW GLEAMS model application, there are output errors in the hydrology and nutrient output files for some of the Illinois River, Baron Fork and Caney Creek HRU's. One example of the output error referenced above is as follows: In the continued waste application scenario ("1.1.FUTURE_100YR", from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\ Gleams_Final), the Illinois River subwatershed hydrology (H20.OUT) and nutrient (N20.OUT) output files for HRU 20 do not contain any model output after day 7 (hydrology) and day 8 (nutrients) of the year 1923 even though the simulation period is set for 1901 to 2000 in this GLEAMS scenario. For further details and a summary of similar output errors in various GLEAMS scenarios, see Table D-2 in Appendix D.

12. In the GLEAMS model, the nutrient input files have an input parameter named CLAB, which represents labile phosphorus concentration in the soil horizon. In the IRW GLEAMS model application, the Illinois River subwatershed nutrient input files for pasture (1NP.PAR and 2NP.PAR, from produced materials Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ 1.1.FUTURE_100YR\ILLINOIS\1NP.PAR, …\2NP.PAR) in the continued waste application scenario (i.e., scenario includes the 1998-2006 phosphorus loads from Dr.

Engel's phosphorus calibration per the e-mail from David Page to Robert George, Louis Bullock; David Riggs, and Elizabeth Claire Xidis on Wednesday, August 13, 2008 8:27 AM, subject "RE: Follow Up Items from July 11 Teleconference with Dr. Engel", stated "...Running YEARLYTP.EXE in the respective subwatershed folders in the 1.1.FUTURE_100YR folder will create a set of outputs including a daily.out file with daily loads. The first 10 years of data in these daily.out files is calibration data for 1997-2006....".) contain CLAB input values that are outside the optimization range set forth in SCE.DAT file (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\SCE.DAT") used in the automated calibration procedure (SCE-UA) of GLEAMS (see Page D-20 in Appendix D of the expert report). The CLAB input values in the 1NP.PAR file range from 37.5-61.7 μg/g and the CLAB input values in the 2NP.PAR file range from 69.4-114.2 μg/g. In contrast, the optimization range set forth in the SCE.DAT file for CLAB ranges from 100-300 μg/g.

Furthermore, the CLAB input value ranges set forth in the SCE.DAT file are inconsistent with how the optimization ranges were described to have been set in the expert report. That is, on Page D-20 in Appendix D of the expert report the following is stated:

> "Calibration parameters were selected by referring to the GLEAMS manual. The GLEAMS manual explains which parameters are most sensitive. Most parameters were generated based on observed data and documented databases so the optimization range was set as ±50% of estimated values to avoid searching extreme values and to insure that calibrated parameters were within reasonable ranges."

The CLAB ranges (100-300 μg/g) set forth in the SCE.DAT file do not represent ±50% of the observed CLAB values listed in Table 6 on Page D-16 in Appendix D of the expert report.

13. In the IRW GLEAMS model application, the Baron Fork subwatershed nutrient input file for pasture (1NP.PAR, from produced materials Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\1NP.PAR) in the continued waste application scenario (i.e., scenario includes the 1998-2006 phosphorus loads from Dr. Engel's phosphorus calibration per e-mail communication referenced in item #12) contain CLAB input values that are outside the optimization range set forth in SCE.DAT file (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\BARRONFORT\SCE.DAT) used in the automated calibration procedure (SCE-UA) of GLEAMS (see Page D-20 in Appendix D of the expert report). The CLAB input values in the 1NP.PAR file range from 37.6-61.9

µg/g. In contrast, the optimization range set forth in the SCE.DAT file for CLAB ranges from 80-150 µg/g.

14. In the IRW GLEAMS model application, the Caney Creek subwatershed nutrient input file for pasture (1NP.PAR, from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\ CANEYCREEK\1NP.PAR) in the continued waste application scenario (i.e., scenario includes the 1998-2006 phosphorus loads from Dr. Engel's phosphorus calibration per e-mail communication referenced in item #12) contain CLAB input values that are outside the optimization range set forth in SCE.DAT file (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\SCE.DAT) used in the automated calibration procedure (SCE-UA) of GLEAMS (see Page D-20 in Appendix D of the expert report). The CLAB input values in the 1NP.PAR file range from 24.3-40.0 µg/g. In contrast, the optimization range set forth in the SCE.DAT file for CLAB ranges from 80-150 µg/g.

15. The original "actual_and_no_litter4_5.xls" (continued waste application and waste application cessation scenario routing model workbook from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\actual_and_no_litter4_5.xls) and the errata "actual_and_no_litter8_30.xls" (continued waste application and waste application cessation scenario routing model workbook from produced materials, Engel\First_Errata\Produced_Considered_Materials\actual_and_no_litter8_30.xls) contain labeling errors in the "Year" label that is used to correlate a particular time (e.g., day/year) with a simulated phosphorus load. The "Year" label in both the summarized GLEAMS output and the summarized routing model output skips years 2047 to 2056.

16. The original "buffer_no_litter.xls" (buffer scenario routing model workbook from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\buffer_no_litter.xls) and the errata "buffer_no_litter8_30.xls" (buffer scenario routing model workbook from produced materials, Engel\First_Errata\Produced_Considered_Materials\buffer_no_litter8_30.xls) contain labeling errors in the "Year" label that is used to correlate a particular time (e.g., day/year) with a simulated phosphorus load. The "Year" label in both the summarized GLEAMS output and the summarized routing model output skips years 2047 to 2056.

17. The "historical_50_99_8_30.xls" workbook, "nps" worksheet (historical scenario routing model workbook from produced materials, Engel\First_Errata\Produced_Considered_Materials\historical_50_99_8_30.xls)

mislabels nonpoint source only loads as nonpoint source plus wastewater treatment plant (WWTP) loads for the Illinois River (Column V), Baron Fork (Column AB), and Caney Creek (Column AD) subwatersheds.

18. The historical (1950-1999) annual loads from the Illinois River, Baron Fork and Caney Creek subwatershed to Lake Tenkiller are incorrect for 25 years out of the 50 years evaluated in the "historical_50_99_8_30.xls" workbook, "nps" and "50 yr" worksheets (historical scenario routing model workbook from produced materials, Engel\First_Errata\Produced_Considered_Materials\historical_50_99_8_30.xls). The error in the annual load summaries arises from an incorrect accounting of the years that are leap years. For example, the annual load for 1952, which is a leap year, only includes 365 days of daily loads and does not include a daily load on day 366. In contrast, the annual load for 1953, which is not a leap year, includes the daily load on day 366 of 1952 plus the other 365 days in 1953 that are actually part of the year 1953. This type of calculation error continues to repeat every two years over the entire 50 year period. The historical scenario results that include these errors are presented on Pages 36-41 of the expert report – Errata September, 4, 2008.

19. The continued poultry waste application and poultry waste application cessation annual loads from the Illinois River, Baron Fork and Caney Creek subwatersheds to Lake Tenkiller were incorrectly calculated for years 2010 (year 10) and 2047-2096 (years 51-100) in the "current_and_no_litter100_8_30.xls" workbook, "cont_cessation" worksheet (from produced materials, Engel\First_Errata\Produced_Considered_Materials\current_and_no_litter100_8_30.xls). The subwatershed annual loads for year 2010 (year 10) include the daily load from day 365 of year 2009. The subwatershed annual loads for years 2047-2096 (years 51-100) are shifted by one day. For example, the annual loads for year 2048 are summed from day 2 of year 2048 to day 1 of 2049.

20. The historical (1950-1999) annual loads from the Illinois River, Baron Fork and Caney Creek subwatersheds to Lake Tenkiller were incorrectly converted from kg to lbs in the "historical_50_99_8_30.xls" workbook, "nps" and "50 yr" worksheets (historical scenario routing model workbook from produced materials, Engel\First_Errata\Produced_Considered_Materials\historical_50_99_8_30.xls). The unit conversion factor applied to convert from kg to lbs was 0.4526; however, the correct conversion factor is 0.45359237 or 0.4536 if rounded up to the fourth significant figure. This error results in an over-estimation of the historical loads over the 50-year period for both the nonpoint source plus point source load and the nonpoint source only load results by 37,898 lbs and 21,857 lbs, respectively. The results are presented on Pages 36-41 of expert report – Errata September, 4, 2008.

21. The observed (1998-2006) annual loads from the Illinois River, Baron Fork and Caney Creek subwatersheds to Lake Tenkiller were incorrectly converted from kg to lbs in the "p_model_10_15.xls" workbook, "Sheet 1" worksheet (from produced materials, from produced materials, Engel\Second_Errata\Produced_Considered_Materials\p_model_10_15.xls). The unit conversion factor applied to convert from kg to lbs was 0.4356; however, the correct conversion factor is 0.4536. This error results in an over-estimation of the observed loads over the 9-year period by 190,682 lbs. The incorrect observed loads are presented in Table 10.1 on Page 47 of the expert report and in Table 10.1 on Page 4 of the expert report – Correction to Errata September, 4, 2008.

22. The 1998-2006 annual GLEAMS loads (P to River) in the "allocation_5_2.xls" workbook, "allocation" worksheet (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\allocation_5_2.xls) do not match any of the base period (1998-2006) GLEAMS model output that was provided in Dr. Engel's produced materials.

23. The annual phosphorus load attributed to point source loads (WWTP's) in the "allocation_5_2.xls" workbook, "allocation" worksheet (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\allocation_5_2.xls) for the 1998-2002 time period was 226,164 lbs/yr (102,588 kg/yr), which is inconsistent with the annual WWTP load listed in Table 6 on Page D-19 in Appendix D of the expert report for the Early 90's to 2002 time period (204,101 lbs/yr or 92,580 kg/yr).

24. The "Year" labels used to identify annual loads to Lake Tenkiller from the routing model output in "Sheet 3" of the "allocation_5_2.xls" workbook (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\allocation_5_2.xls) are incorrect and have been mislabeled. The annual loads are labeled as routing model output from 1998-2006 (or years 2-10); however, based on the "current_and_no_litter100_4_25.xls" workbook, "no litter back p" worksheet (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Bernard Engel considered materials\current_and_no_litter100_4_25.xls) the correct "Year" labels based on the "no litter back p" worksheet should be 2057-2065 (or years 51-59). However, it is important to note that the 2057-2065 "Year" labels would still be incorrect because of an additional error in the "current_and_no_litter100_4_25.xls" workbook. The "Year" labels in the routing model output in the "current_and_no_litter100_4_25.xls" workbook skip years 2047- 2055. The correct "Year" labels for the routing model loads labeled 1998-2006 are 2047-2055. The routing model results from "Sheet 3" of the "allocation_5_2.xls" workbook are used to determine the load allocations for individual sources as summarized in Table 10.14 and Table 10.15 on Page 93 of the expert report.

25. The method used to add the WWTP loads to the GLEAMS nonpoint source (NPS) model output (e.g., post-processing software application or manual post-processing in an Excel workbook) was not documented in the expert report.

26. The expert report does not provide any documentation or explanation on how the 14 soil types, listed in Figure 5 on Page D-10 in Appendix D of the expert report, were aggregated or lumped into the four soil types listed on Pages D-14 to D-15 in Appendix D of the expert for the IRW GLEAMS model application.

27. The Shuffled Complex Evolution Algorithm (SCE-UA) calibration procedure was applied to the 2NP.PAR (input file for Zone 3) (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\CD_Received_July 17 \CD_Received_July 17\SecondStage\ILLINOIS\2NP.PAR or Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\ \Gleams_Final\1.1.FUTURE_100YR\ILLINOIS\2NP.PAR) nutrient input file for pasture in the GLEAMS application to the Illinois River subwatershed and applied to the 1NP.PAR (input file for Zone 1 and Zone 4) (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\CD_Received_July 17 \CD_Received_July 17\SecondStage\ BARRONFORT or Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ 1.1.FUTURE_100YR\BARRON FORT\1NP.PAR and Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\Gleams_Final\1.1.FUTURE_100YR\CANEYCREEK\1NP.PAR) nutrient input file for pasture in the GLEAMS application to the Baron Fork and Caney Creek subwatersheds. The calibration procedure for the 1NP.PAR (input file for Zone 2) (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\CD_Received_July 17 \CD_Received_July 17\SecondStage\ILLINOIS\1NP.PAR or Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ 1.1.FUTURE_100YR\ILLINOIS\1NP.PAR) was not documented. The calibration procedure for the other nutrient inputs files (1NC.PAR, 1NF.PAR, and 1NU.PAR) in Zones 1-4 (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\CD_Received_July 17 \CD_Received_July 17\SecondStage\subfolders… "ILLINOIS" and "BARRONFORT" or Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\Gleams_Final\ 1.1.FUTURE_100YR\ … subfolders "ILLINOIS", BARRONFORT", and "CANEYCREEK") for crop, forest and urban land uses was also not documented.

28. The method and/or approach used to model buffers in the two buffer scenarios (buffers along all 3rd order and larger IRW streams; buffers along all IRW streams) presented in the expert on Pages 67-75 and the expert report – Errata September, 4, 2008" on Pages

22-29 was not documented in either the expert report or the expert report – Errata September, 4, 2008.

29. On Page D-18 in Appendix D of the expert report, the following statement, "Fertilizer in GLEAMS was set as animal waste (MFERT=1) for poultry waste and applied April 1 (NF=91 as Julian day)" contains an error. The parameter input for the date of fertilization in GLEAMS is denoted DF, not NF. In GLEAMS, the parameter input NF, is the number of fertilizer and animal waste applications during the update period.

30. The x-axis in Figure 11 on Page D-28 in Appendix D of the expert report is mislabeled. The "Year" label in x-axis ranges from 1996-2005. However, the correct "Year" label should range from 1986-1995, which is the hydrologic validation period as noted on Page D-27 in Appendix D of the expert report. Furthermore, based on the "Results2.xls" workbook (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials\Materials\GLEAMS\Results2.xls) and the hydrology validation HYDRES.OUT file (from produced materials, Engel\Original_Expert_Report\Produced_Considered_Materials \Materials\GLEAMS\Application\Runoff_val\Illinois River\Model\HYDRES.OUT), the data plotted in Figure 11 are incorrect and do not represent the final hydrology validation results.

31. The x-axis in Figure 12 on Page D-28 in Appendix D of the expert report is mislabeled. The "Year" label in x-axis ranges from 1996-2005. However, the correct "Year" label should range from 1986-1995, which is the hydrologic validation period as noted on Page D-27 in Appendix D of the expert report.

32. The x-axes and y-axes in Figures 15, 16, 17, 18, 19, and 20 on Pages D-32 to D-34 in Appendix D of the expert report are missing constituent load labels, as well as unit labels for the daily predicted and observed phosphorus loads plotted.

33. The x-axes and y-axes in Figures 15, 16, 17, 18, 19, and 20 on Pages 45-48 in the expert report – Errata September, 4, 2008 are missing constituent load labels, as well as unit labels for the daily predicted and observed phosphorus loads plotted.

34. The y-axes in Figures 10.37, 10.38, 10.39, and 10.40 on Pages 89-90 in the expert report are missing constituent concentration labels, as well as unit labels for the average phosphorus concentrations plotted.

35. The y-axes in Figures 10.37, 10.38, 10.39, and 10.40 on Pages 41-43 in the expert report – Errata September, 4, 2008 are missing constituent concentration labels, as well as unit labels for the average phosphorus concentrations plotted.

36. In the expert report – Errata September, 4, 2008, the Illinois River near Tahlequah calibration and validation results were switched. Figure 15 on Page 45 is incorrectly described as "Calibration for Daily P Load at Tahlequah". Based on the source file for this figure (from produced materials, Engel\Second_Errata\Produced_Considered_Materials\p_model_10_15.xls), the correct description for Figure 15 is "Validation Results for Daily P Load at Tahlequah".

37. In the expert report – Errata September, 4, 2008, the Baron Fork at Eldon calibration and validation results were switched. Figure 16 on Page 46 is incorrectly described as "Calibration Results for Daily P Load at Baron Fork near Eldon". Based on the source file for this figure (from produced materials, Engel\Second_Errata\Produced_Considered_Materials\p_model_10_15.xls), the correct description for Figure 16 is "Validation Results for Daily P Load at Baron Fork at Eldon".

38. In the expert report – Errata September, 4, 2008, the Caney Creek near Barber calibration and validation results were switched. Figure 17 on Page 46 is incorrectly described as "Calibration Results for Daily P Load at Caney Creek". Based on the source file for this figure (from produced materials, Engel\Second_Errata\Produced_Considered_Materials\p_model_10_15.xls), the correct description for Figure 17 is "Validation Results for Daily P Load near Caney Creek".